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Harvester 1.0

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by Andy Sorensen

A Terminal Project

Presented to the Faculty of

The College of Architecture at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Architecture

Major: Architecture

Under the Supervision of Professor Brian Kelly

Lincoln, Nebraska

May, 2011

Harvester 1.0

Decreasing Farmland +

Increasing Development +

A Growing Digital Environment

Harvester 1.0

Statement:

bringing agriculture into the urban environment through the creation of *hybrid architectural programs* mutualistically related to one another and with the necessary urban utility-infrastructure that is supporting today's growing digital world

Abstract:

One critical topic has always remained constant throughout the life of this thesis: efficient and multi-functioned urban land use.

It began with the questioning of golf courses and how much land they consumed for typically only a single, recreational function. After realizing the more direct and architectural programmatic relationships, the project shifted to the incorporation of farming into the urban environment while also linking it to today's growing digital infrastructure needs. This thesis is a means of exploration through process and not necessarily an end result. The questions and potential that this project raises about the architectural relationships is what provides the inner strength.



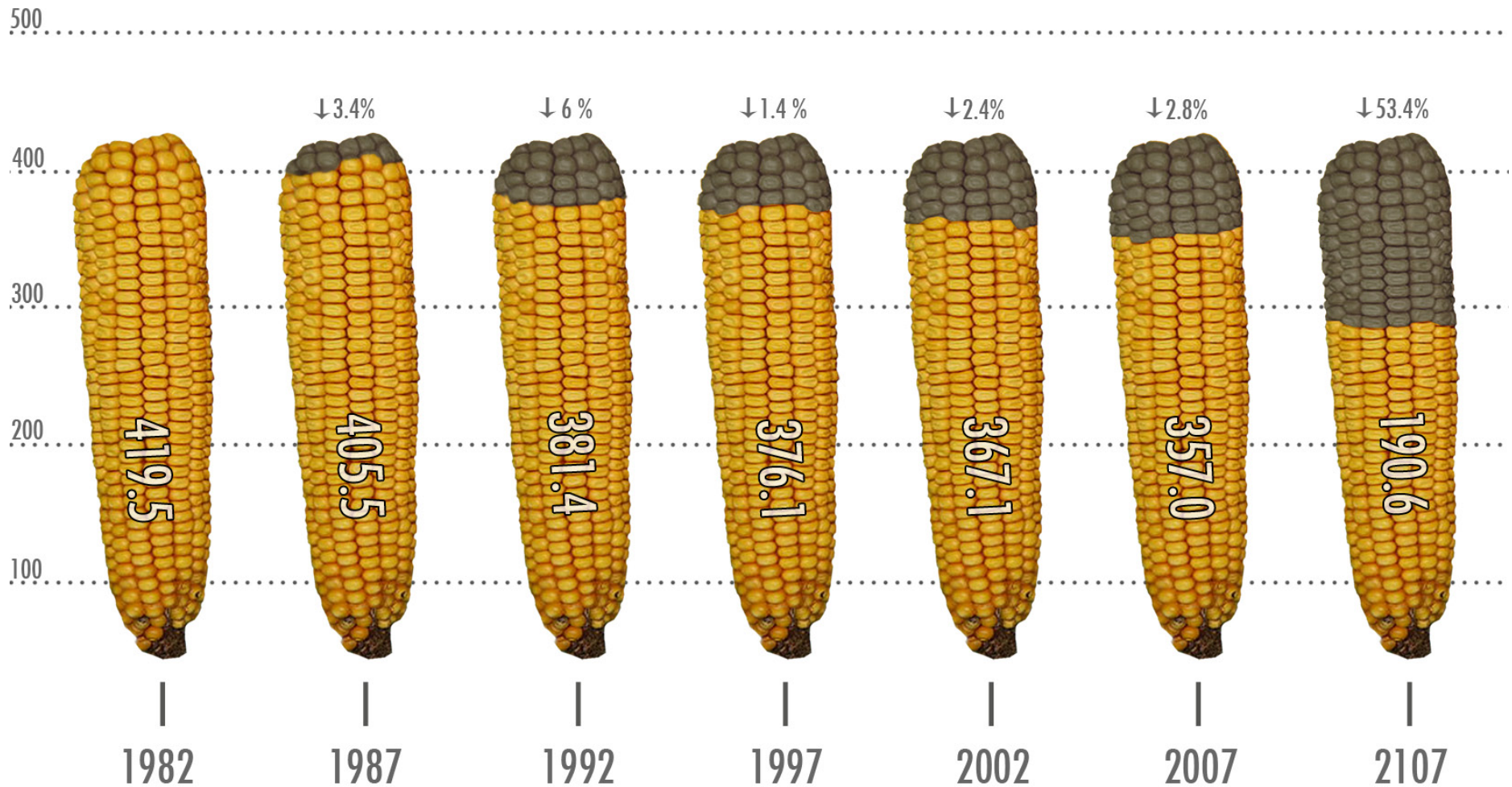
1. Issues	01-12	4. Design Solution	65-80
<ul style="list-style-type: none">- Farmland Depreciation- Increasing Development- Eating Local- Server Growth- Energy Monsters		<ul style="list-style-type: none">- Project Characteristics- Site Plan- Main Plot Level and Lobby Market Plan- Longitudinal Section and Tower Floors- Basement Level Plan and Perspective- Transverse Section- Perspective Series- Final Model	
2. Programs and Precedent	13-24	5. Final Thoughts	81-86
<ul style="list-style-type: none">- Data Centers- Solar Towers		<ul style="list-style-type: none">- Acknowledgments- Closing Remarks- Bibliography	
3. Schematic Design - Process	25-64		
<ul style="list-style-type: none">- Site Selection and Photos- Site Analysis- Design Iteration and Sketching- Site Criteria- Growth System- Design Concepts			

Every minute of every day,
more than an acre of **farmland**
is converted **to development**
(American Farmland Trust)

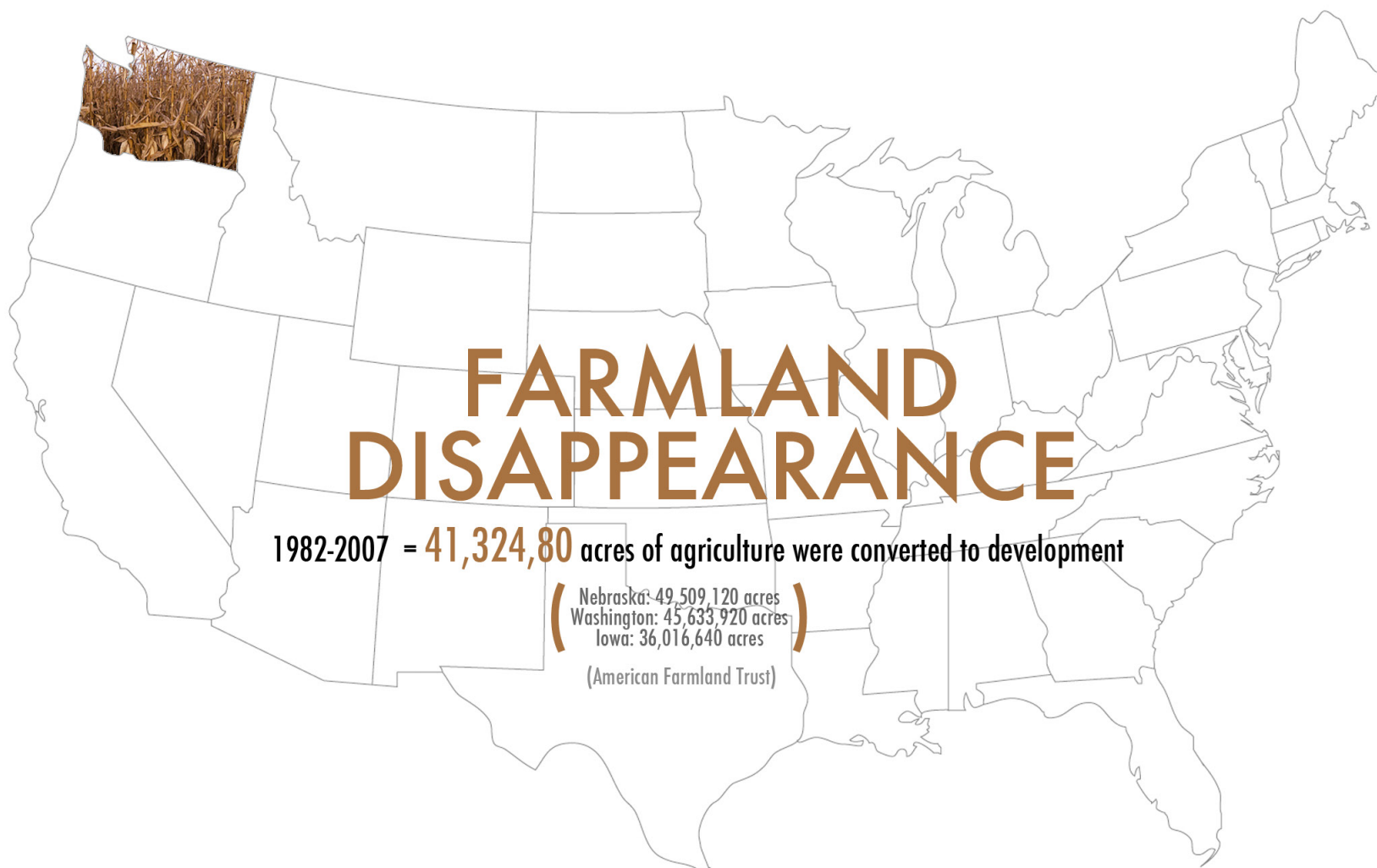
Amount of Cropland in the United States (millions of acres)

Source: National Resource Inventory 2007 Report

If trends continue, it is estimated that the United States will lose over 150 million more acres in the next 100 years

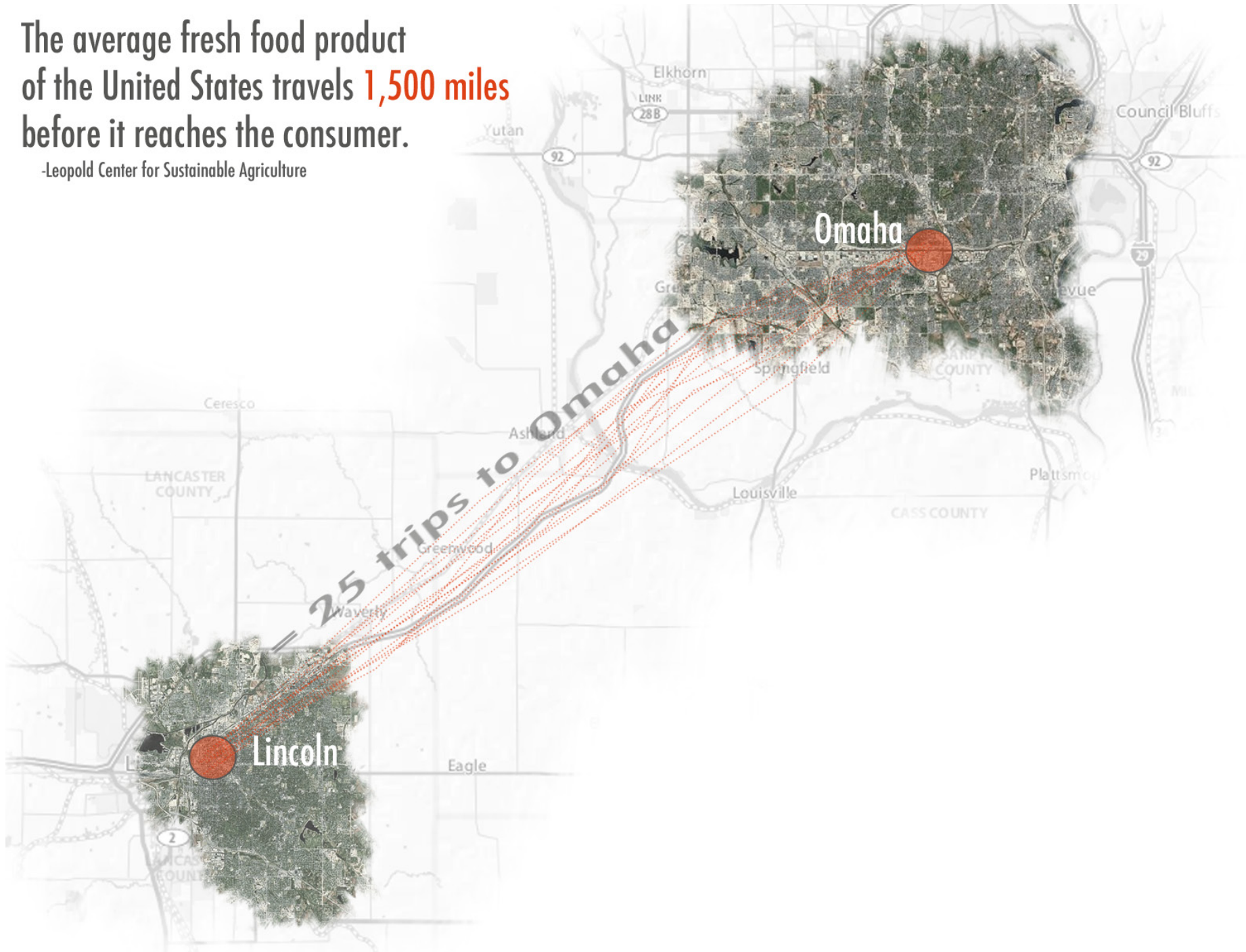


The farmland disappearance between 1982-2007 is nearly equal in size to the entire state of Washington



The average fresh food product
of the United States travels **1,500 miles**
before it reaches the consumer.

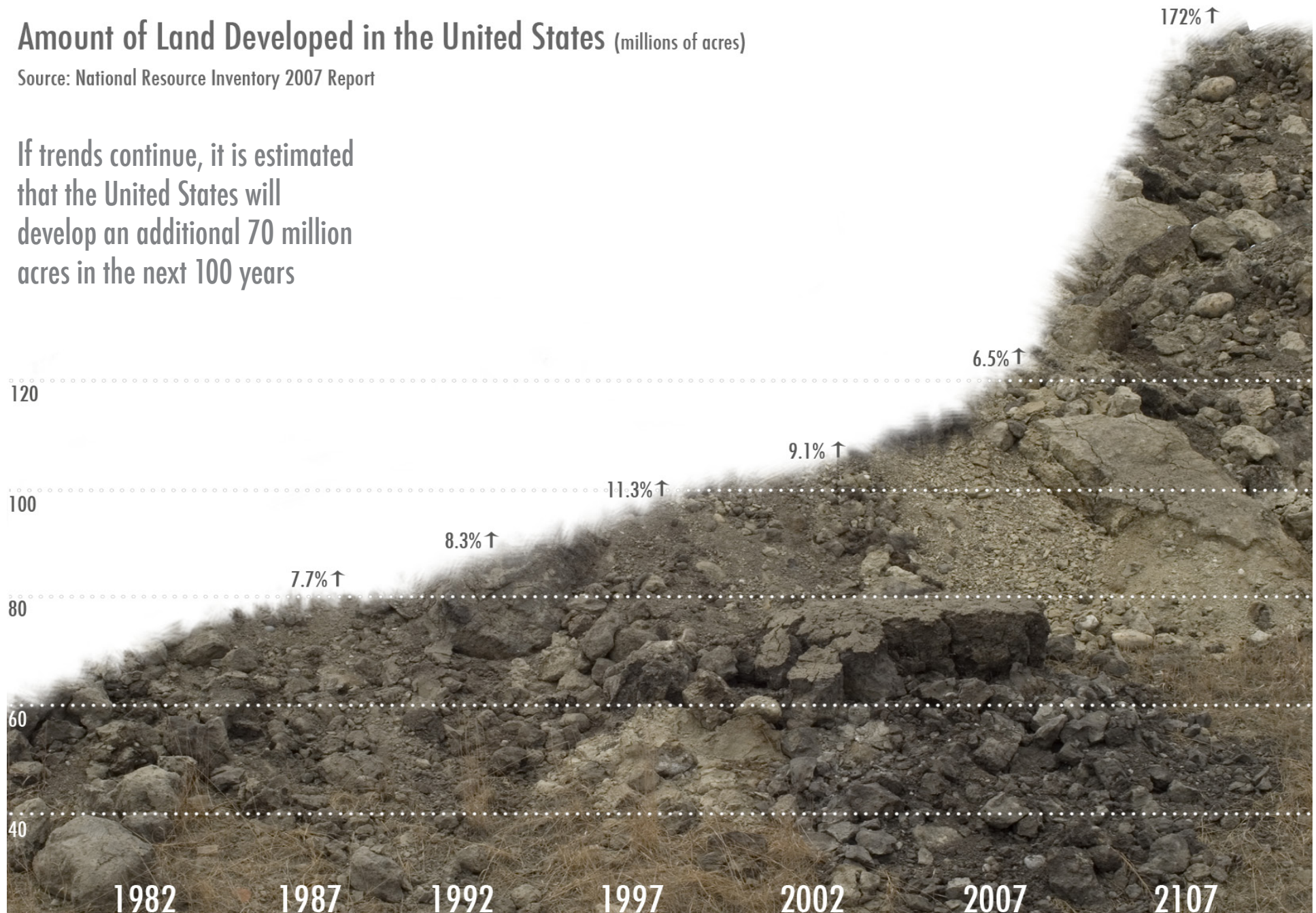
-Leopold Center for Sustainable Agriculture



Amount of Land Developed in the United States (millions of acres)

Source: National Resource Inventory 2007 Report

If trends continue, it is estimated that the United States will develop an additional 70 million acres in the next 100 years

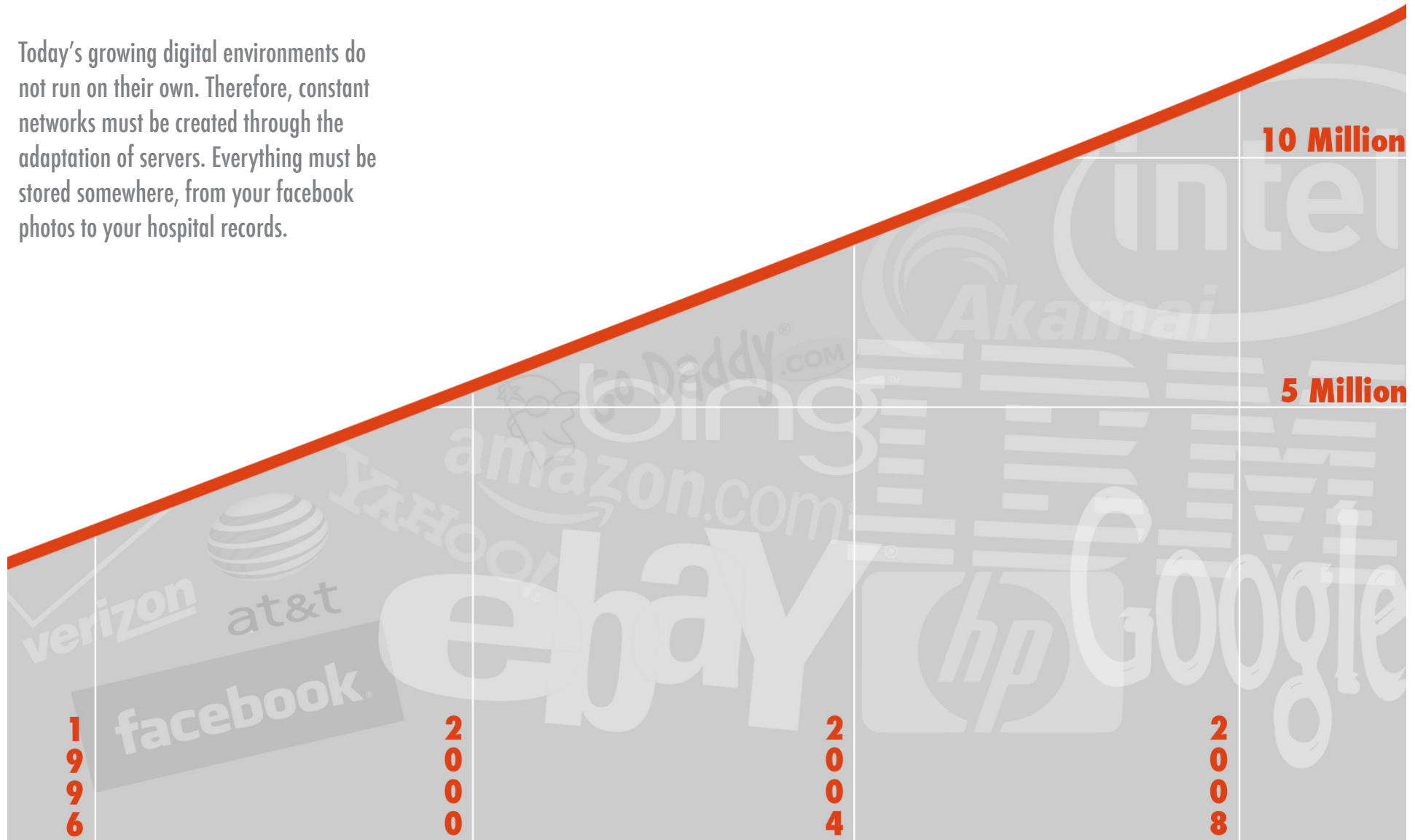


Total Amount of Servers in the United States:

2.6 million to 11.8 million
(A 450% increase from 1997-2007)

-Source: IDC

Today's growing digital environments do not run on their own. Therefore, constant networks must be created through the adaptation of servers. Everything must be stored somewhere, from your facebook photos to your hospital records.



It is estimated that an additional **10 power plants** will be needed to power the data server growth from 2007-2011 (2007 EPA Report)

Data Related - Average Electricity Use in the United States

(From individual servers
to power plant requirements)



1 server: 250 watts

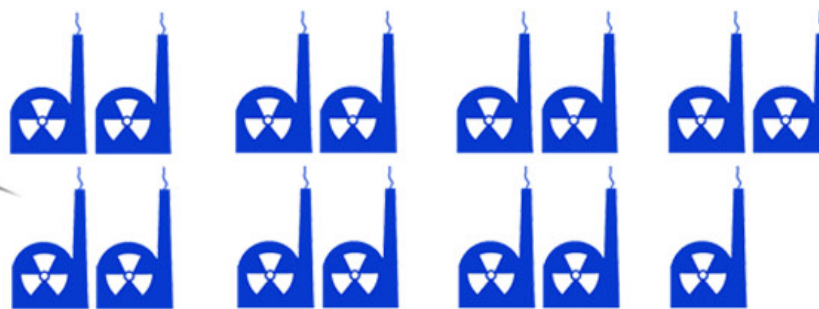
[1000 watts per kw-h
1000 kw-h per mw-h
1000 mw-h per gw-h]



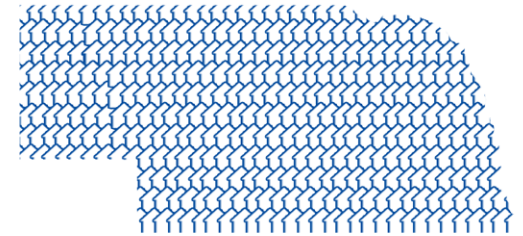
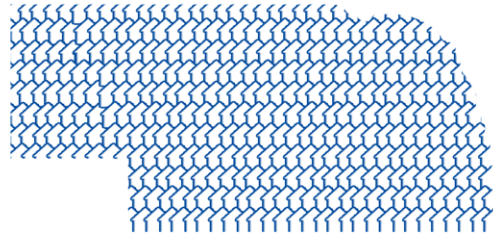
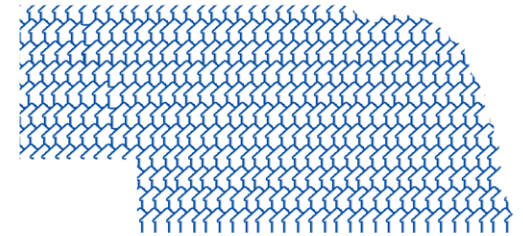
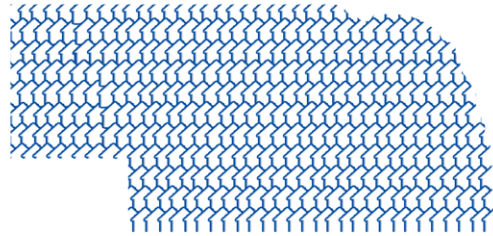
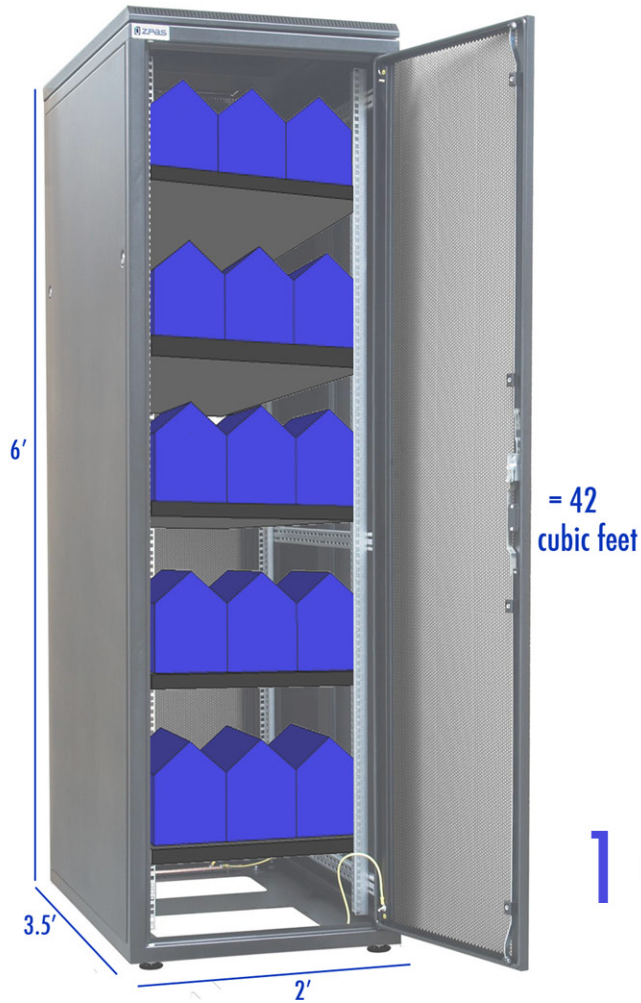
1 server rack: 20-25 kw-h



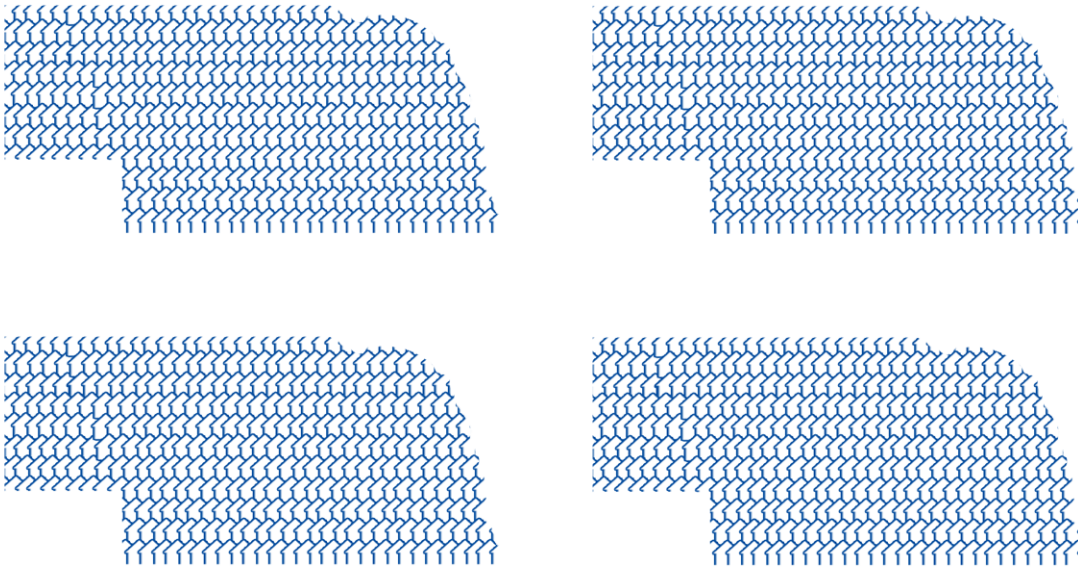
Nationwide Usage: 7 gw-h or 7 bililion watts



Power Required: 15 baseload power plants



1 Server **Rack** = **15** Peak Load California **Homes**
-Environmental Protection Agency Report 2007



Each year data centers contribute to 1.5% of the total consumed energy in the United States, which might not sound like much at first, but is:

Enough to power all of the households in Nebraska...

8 TIMES OVER

Worldwide, Data Centers use more energy than the entire country of Sweden

(NY Times: Data Center Overload)

Data Centers:

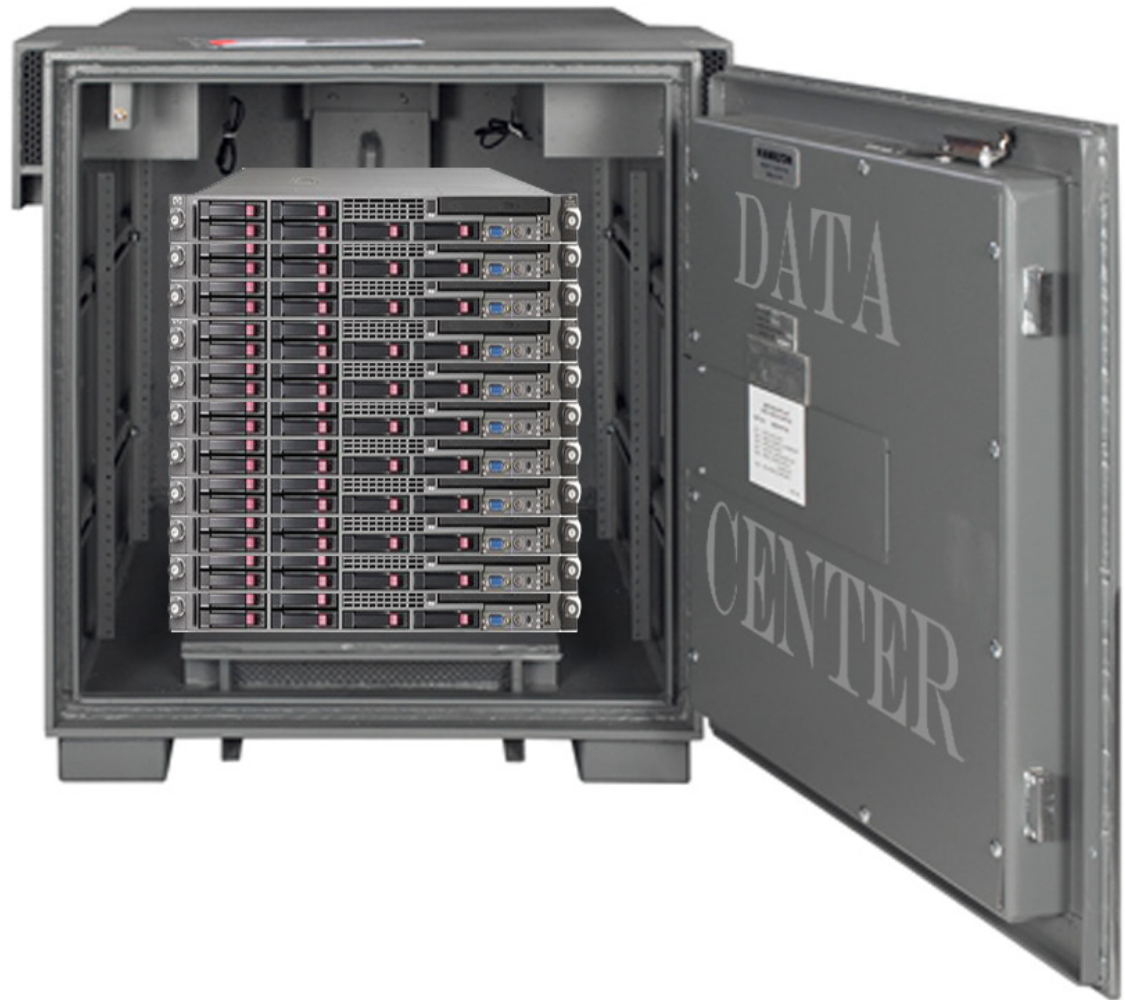
What are they?

A facility that is used primarily to house computer systems or servers along with their associated components

-Also termed server farms

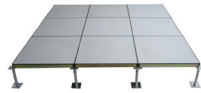
Include: redundant or backup power supplies, redundant data communication connections, environmental controls like air conditioning and fire suppression and security devices

In simplest terms, it is a building focused around the security and performance of servers in order to maintain a stable virtual environment



Two Forms:

1. Raised Floor
2. Container



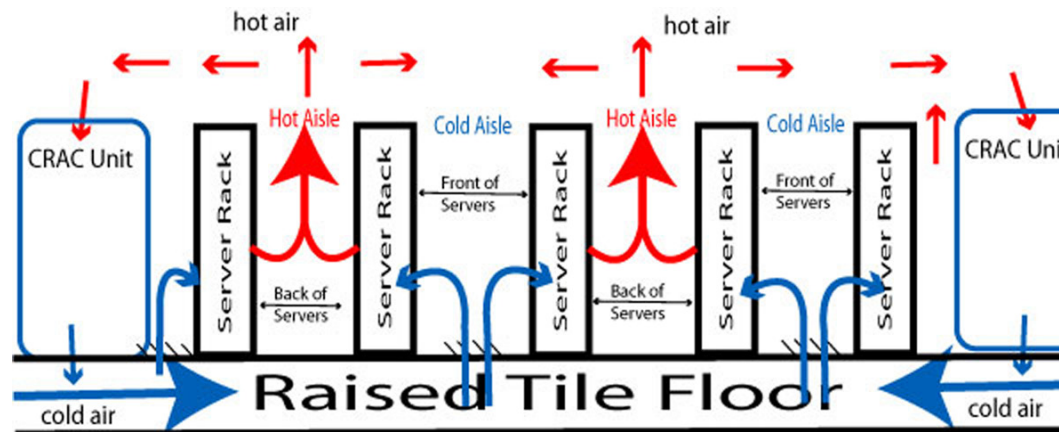
Traditionally the most common form

Leaves 2-3 ft of space underneath the servers for mechanical delivery and electrical support

Design around the cold and hot aisle is key for minimal air mixing

Must plan for expandability, otherwise building addition is required

Planned around available electricity capacity, not necessarily square footage



Two Forms:

1. Raised Floor
2. Container



A single 40 ft. shipping container can hold around 17-19, 19 inch racks or approximately 2,000 servers

It's an all-inclusive design, which features: the servers, cooling system, power distribution, fire suppression and heat exchanging units

Back-up power provided separately

Many vendor neutral companies are producing these units, but companies like IBM, google, Microsoft and HP have developed their own versions



Bing Maps, "Battlestar Galactica" container



HP Pod Container: Performance Optimized Data Center

“Data Center in a box”
Easy, Scalable

Contains 22, 19 inch racks
High density: 600 total KW, or 27 KW per rack. Racks go from floor to ceiling and are anchored at both ends, which completely separates the hot and cold aisle

Cold aisle can go as high as 90 deg for max efficiency. Most IT equipment can function up to 95 deg, which means they can send in 55-75 degree chilled water rather than 45 degree

Goes into other structures or stand alone

Typically takes 24-36 months to construct a brick and mortar data center, but these PODs can be shipped out in 6 weeks



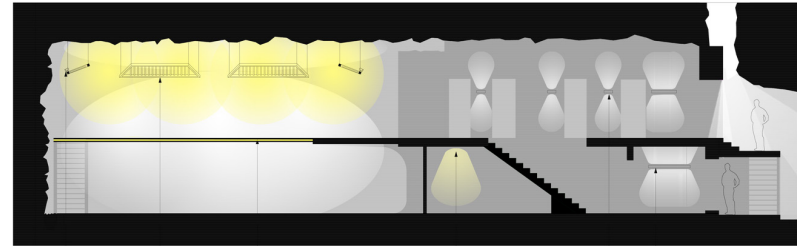
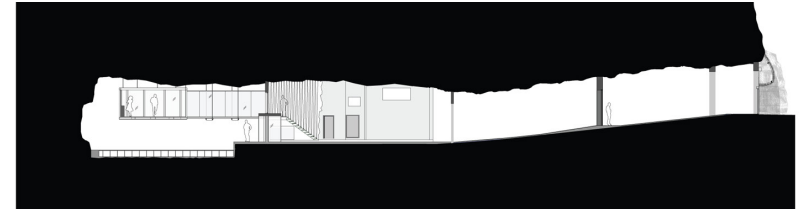
White Mountain Data Center: AFL Architects

Location: Stockholm, Sweden

Buried 98 ft. underground in
an atomic bomb shelter

Tried to bring natural elements
down underground

Utilized the underground environment
for stable, cooler temperatures



Uspenski Data Center

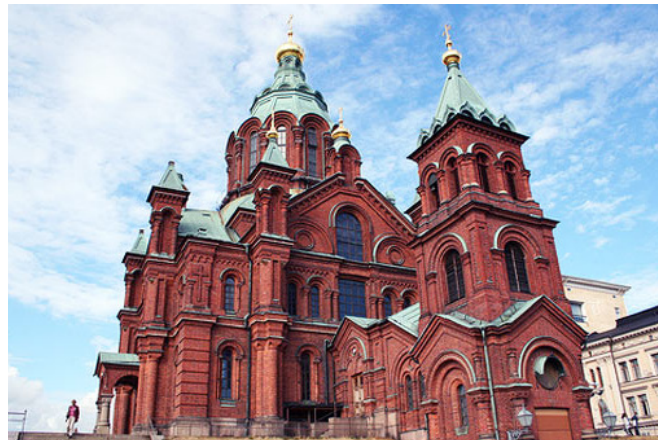
Location: Helsinki, Finland

Located underneath the famous Helsinki Cathedral in a WWII bomb shelter

The data center captures heat produced by the equipment below and then uses it to help heat the homes above ground. Helsingin Energia developed the waste heat redistribution technology

Expected to save 561,000 dollars per year of electricity cost

This small scale example produces about the amount of energy as one large wind turbine (1 MW) or 500 large homes



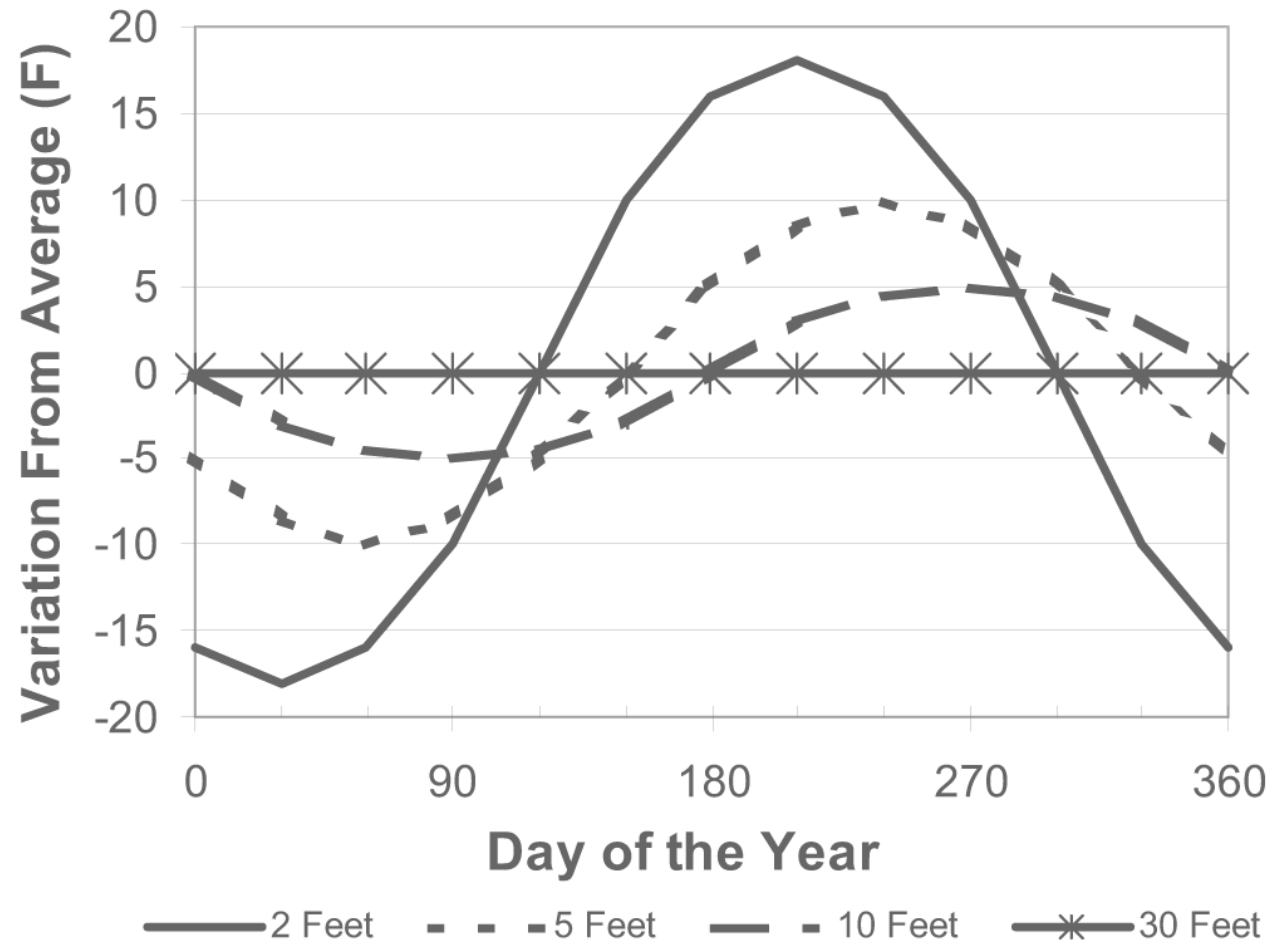
ASHRAE Map: Reason for Building Underground

Over half of the electricity usage of a data center is used to help cool the equipment, not necessarily to power the servers

By building underground it is possible to take advantage of the cooler, consistent temperatures

Average yearly temperature in Omaha, NE is approximately 50 degrees

Building underground would allow for less of a mechanical cooling load



Solar Towers:

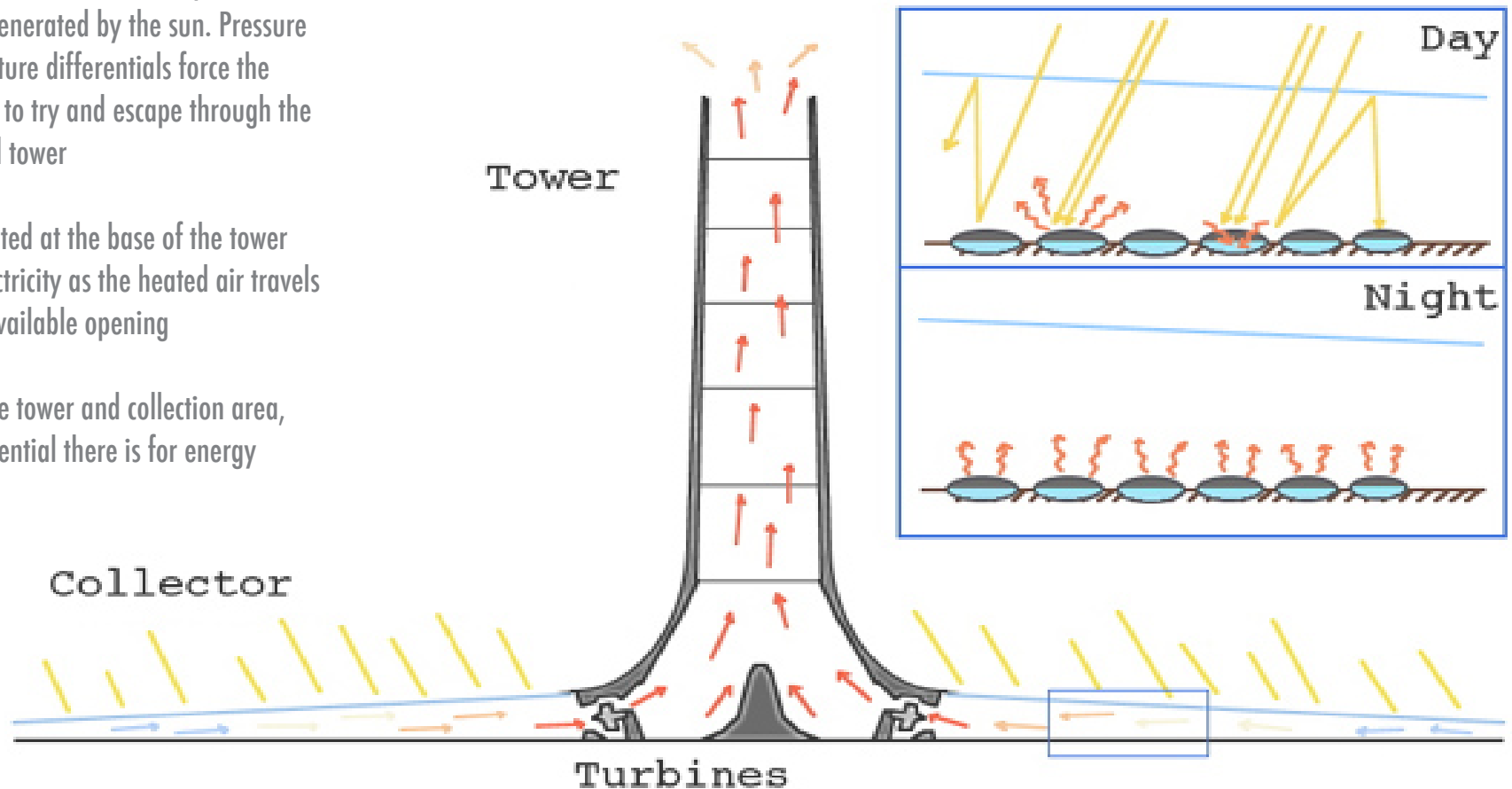
What are they?

Solar towers depend on natural phenomena to generate electricity

A large greenhouse structure captures and stores heat generated by the sun. Pressure and temperature differentials force the trapped heat to try and escape through the large, central tower

Turbines located at the base of the tower generate electricity as the heated air travels to the only available opening

The larger the tower and collection area, the more potential there is for energy generation



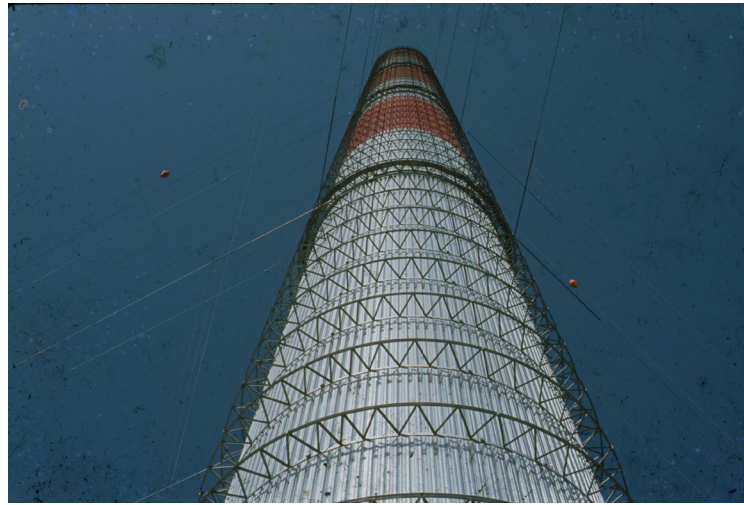
Manzanares, Spain Tower:

Designed as a scaled prototype in 1982
primarily for testing greenhouse materials

It was consistently able to produce
50KW of electricity

It stood 640 ft. high, had a diameter of 32
ft. and an 800 ft. diameter collection area

Helped prove that solar towers can indeed
produce electricity and this example
actually outlived its intended life span



Enviromission Australia Proposal

Massive scale for power plant like capacities

Planned to be 3281 ft. tall, 426 ft in diameter and have a collection area diameter of over 16,000 ft

Capable of producing 200 MW of electricity

Arizona is currently considering building two of these solar towers. If completed, the structures would become the tallest in the world



The **challenge** is to incorporate these solar towers into an urban environment, linking them to urban agriculture and redensifying the city. Then people will get to experience the structure and the new architectural relationships that are created.

Site: Omaha, NE

Population: 427, 872

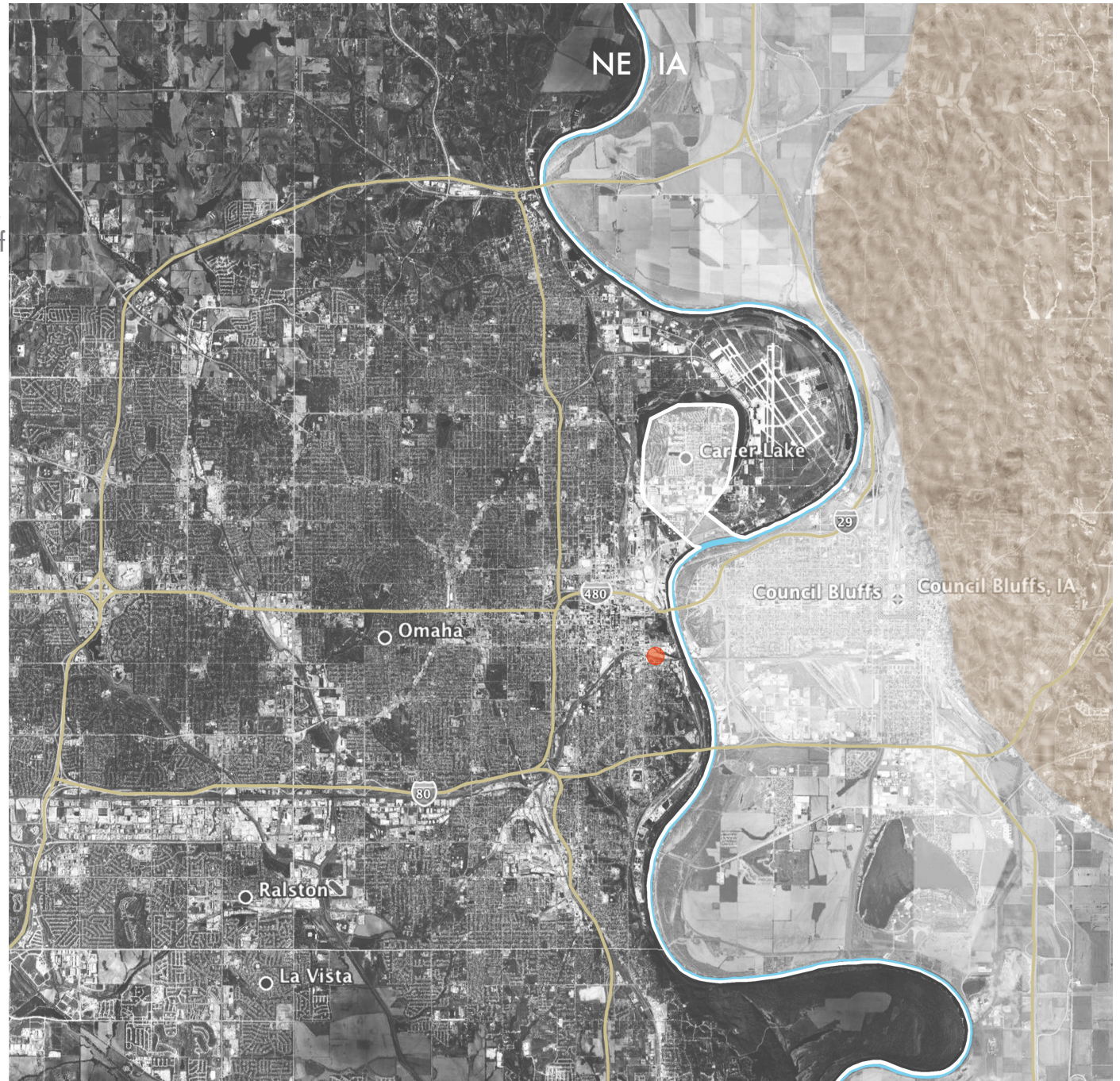
Size: 100 sq. miles

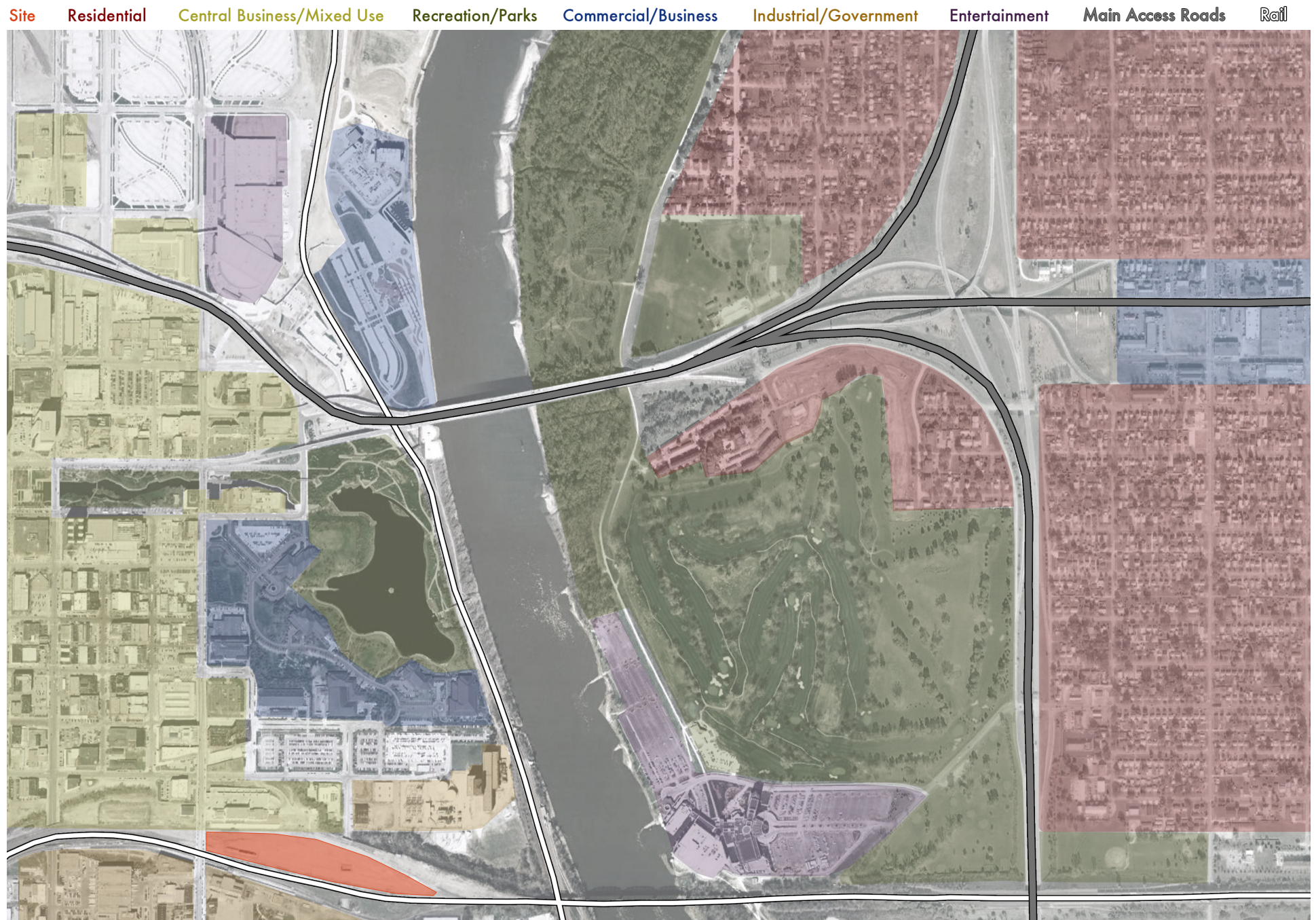
Why Omaha?

- Significant tax breaks for data centers locating there
- Abundant sources of electricity
- Cheap electricity
- An urban environment that Could benefit from re-densification
- High quality of living for new employees

Early Site Analysis

The first map on the left analyzes site aspects on a more macro scale, such as arterials and natural typological boundaries; while the second map on the right zooms in on the site more and addresses the different functions of the land in the vicinity of the selected site. In both cases, the site is highlighted in orange.







Industrial Defunct:

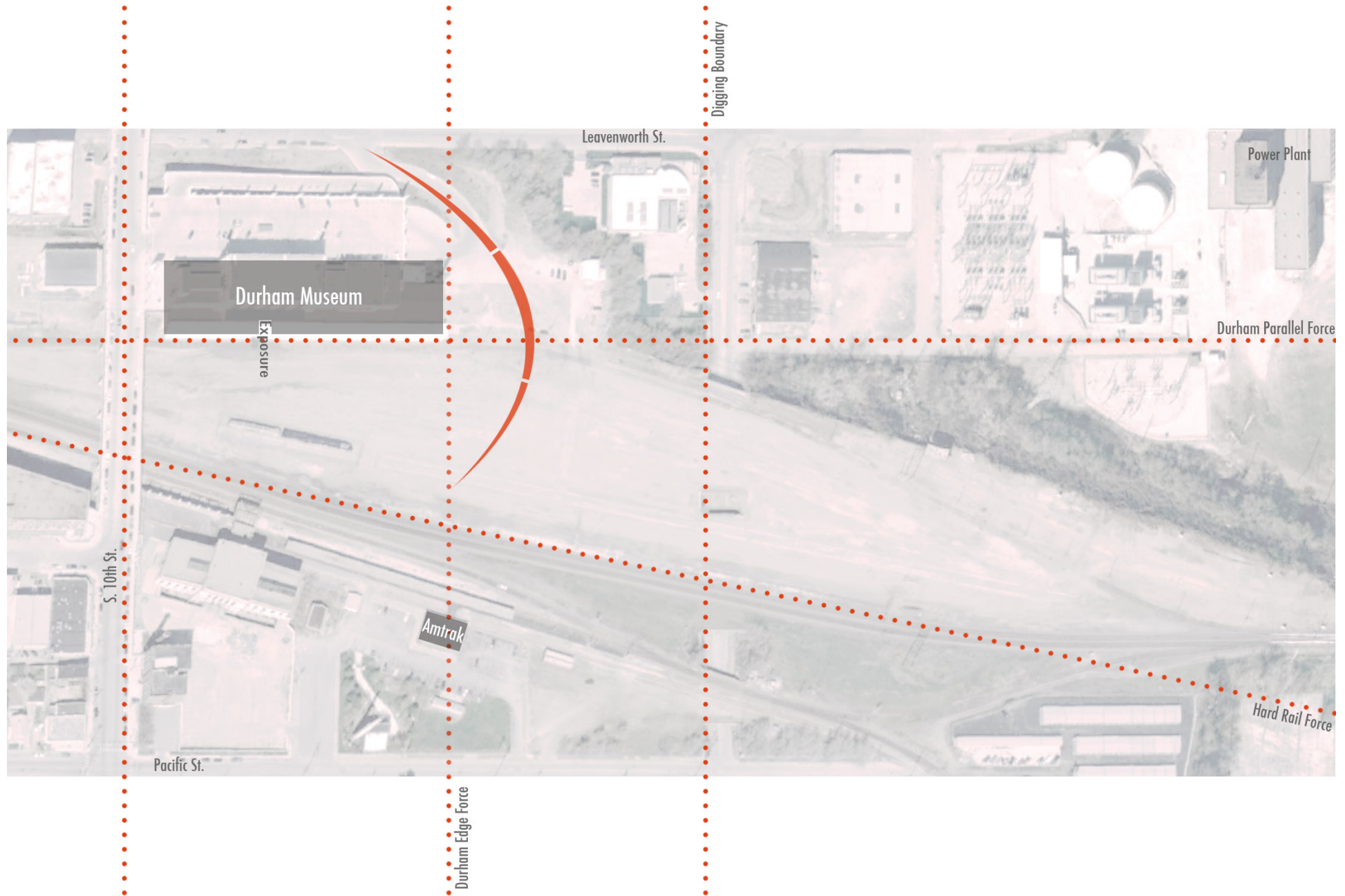




Hub Site



Site Forces Analysis

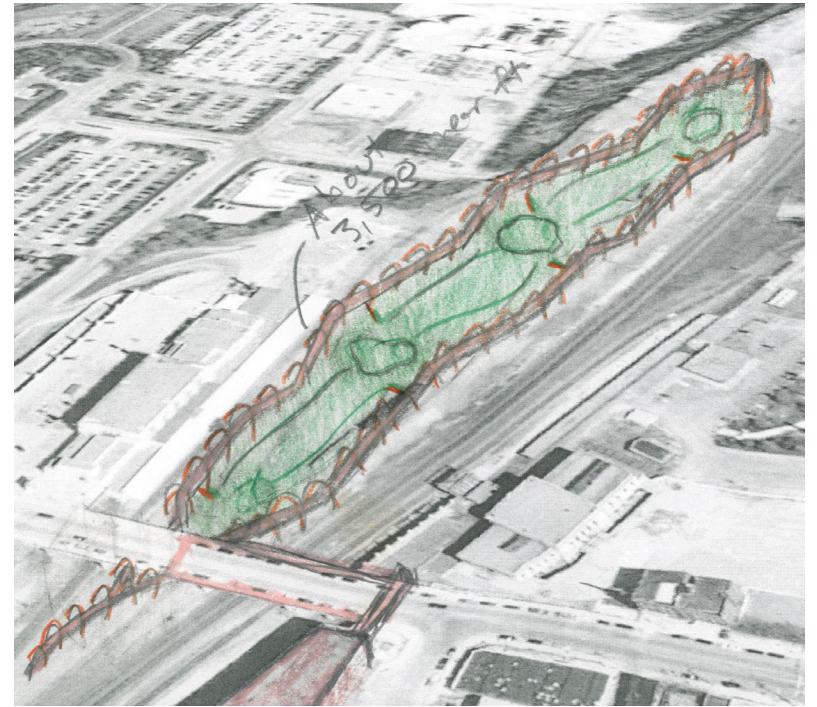
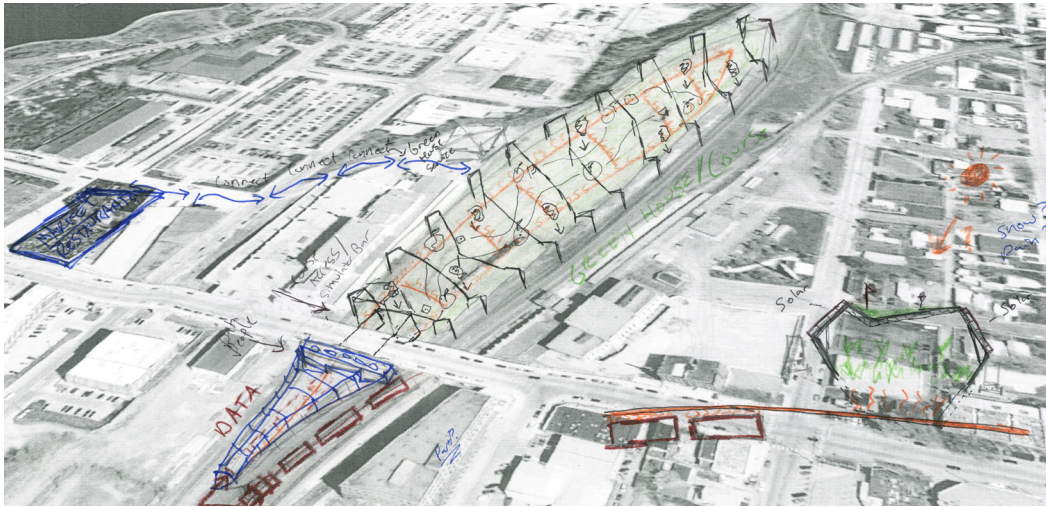


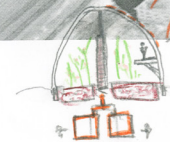
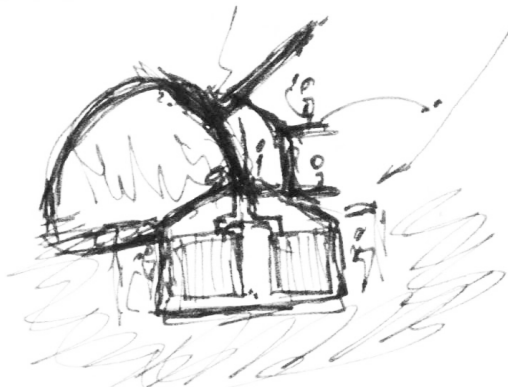
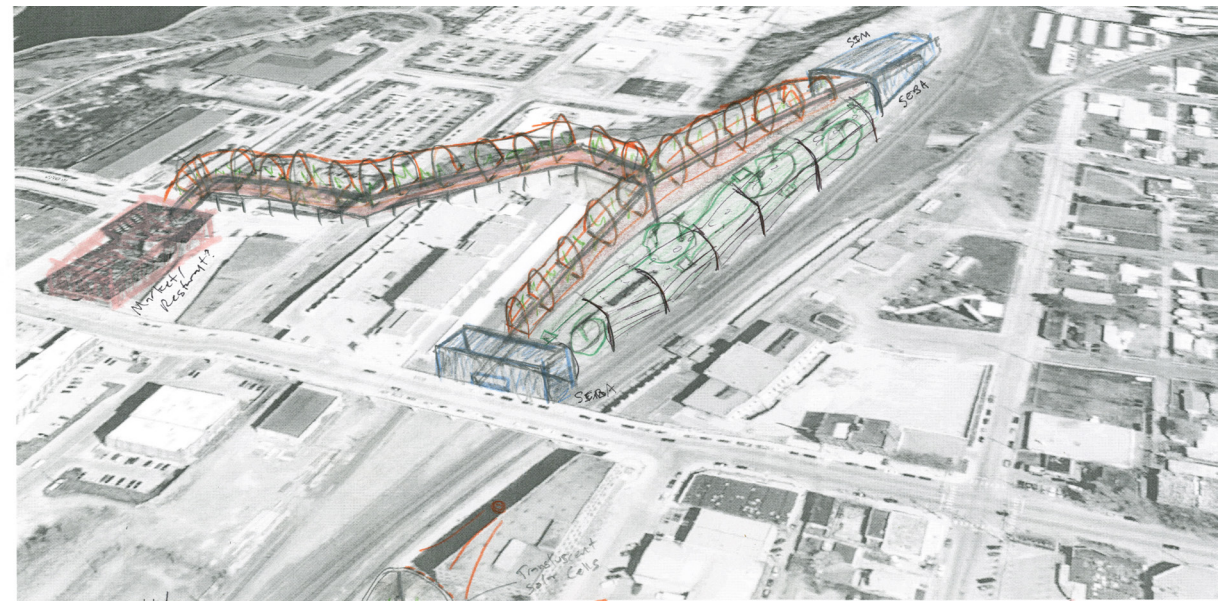
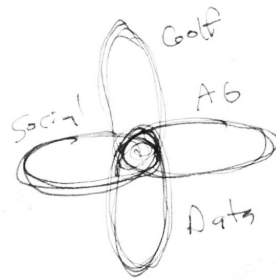
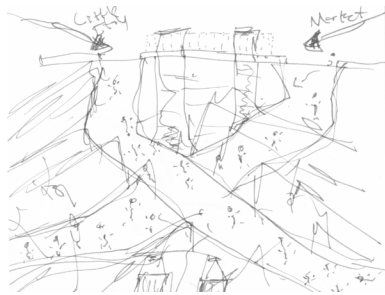
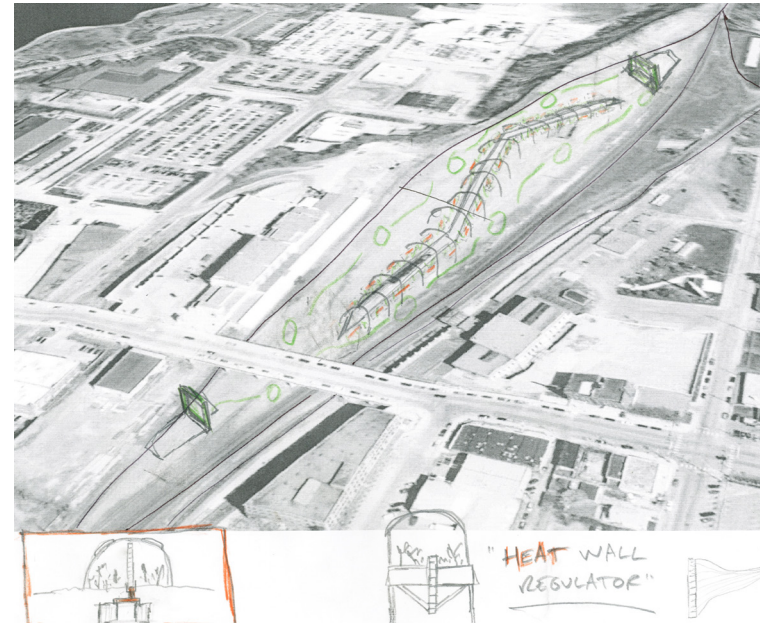
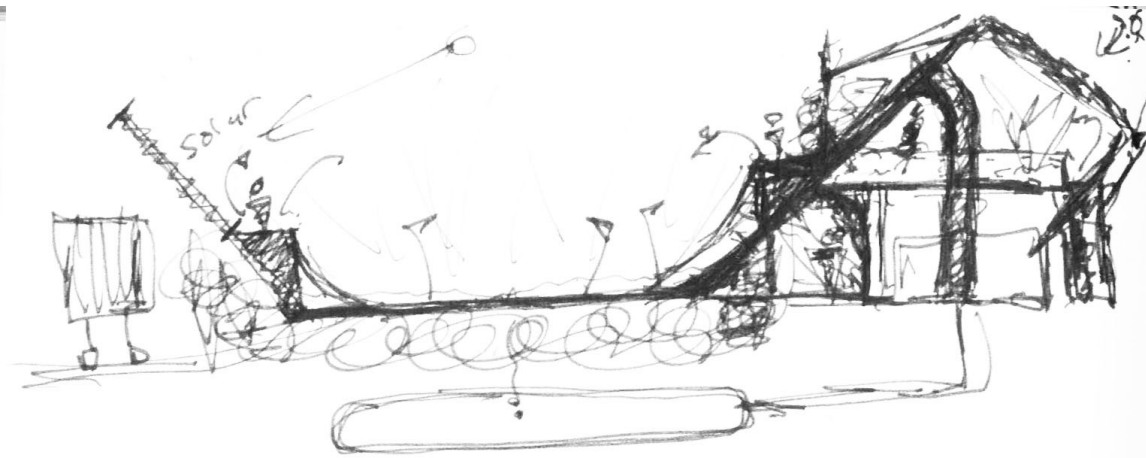
Beginning Ideas

Although the incorporation of a golf course was eventually dropped in the project's process, this diagram still speaks true to some of the main ideas. It addresses ways in which we can make our land more multi-functional. Rather than having a large piece of land that typically only provides a single-function, perhaps it is better to look into ways in which we can make the precious land we have more efficient and beneficial to the surrounding population.

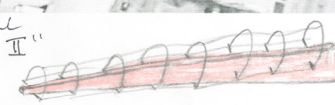


These early ideas attempted to mix the overall layout of the project with more micro elements, such as sectional relationships and forms. Even at this early of a stage, some schemes start to hint at connecting different urban conditions. A heat wall concept was important early on when a more passive heating system was considered.





"HEAT WALL REGULATOR II"

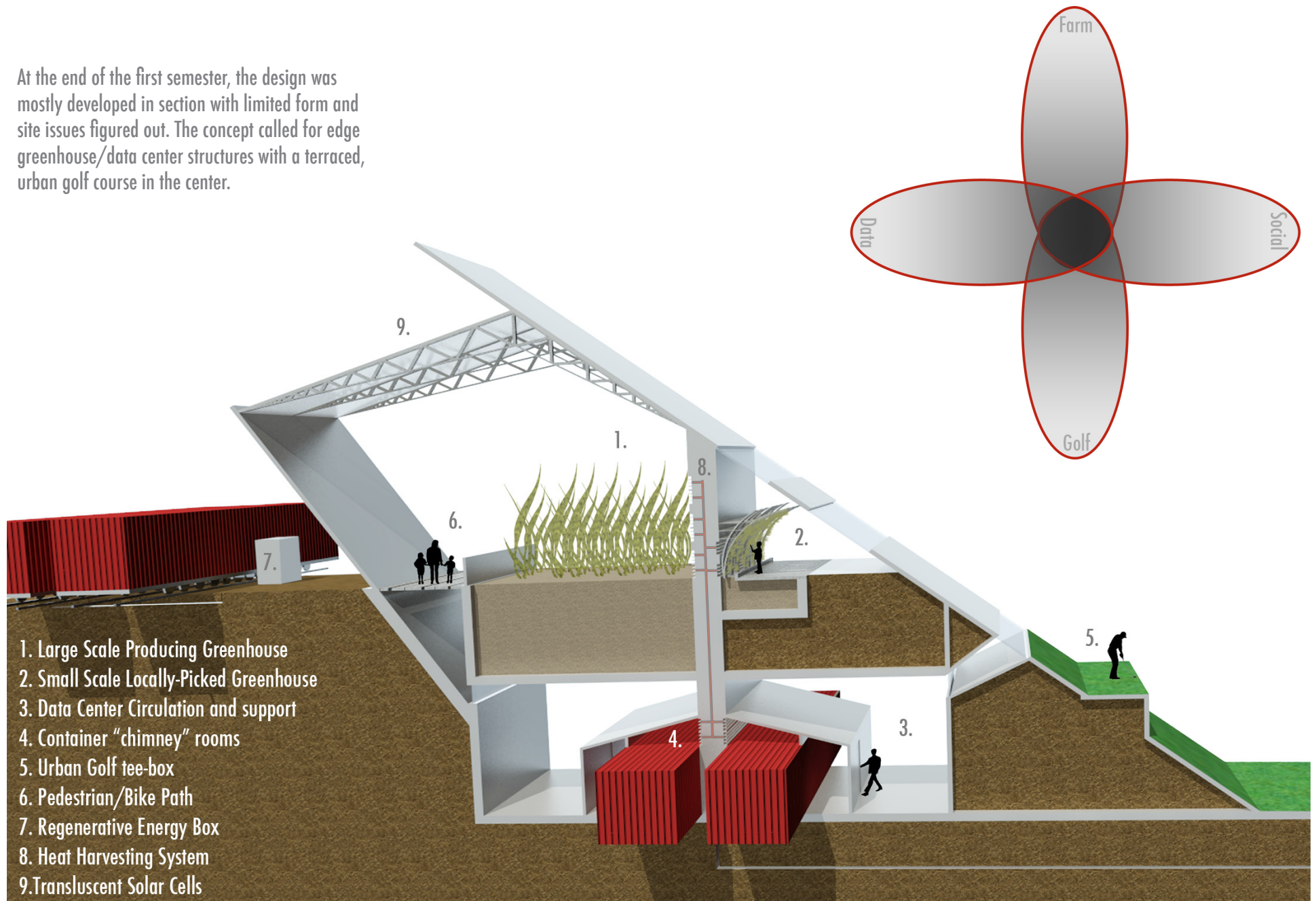


WALL THICKNESS CHANGES DEPENDING ON HEAT UPLIFT REQUIRED

1st Semester Schematic Proposal (golf course included)



At the end of the first semester, the design was mostly developed in section with limited form and site issues figured out. The concept called for edge greenhouse/data center structures with a terraced, urban golf course in the center.

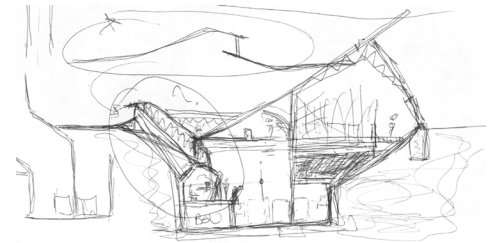


Re-defined Process: New Direction

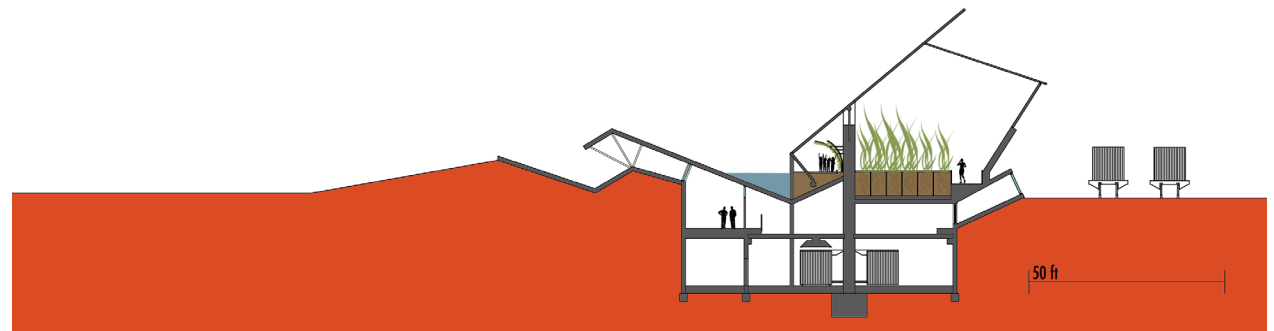
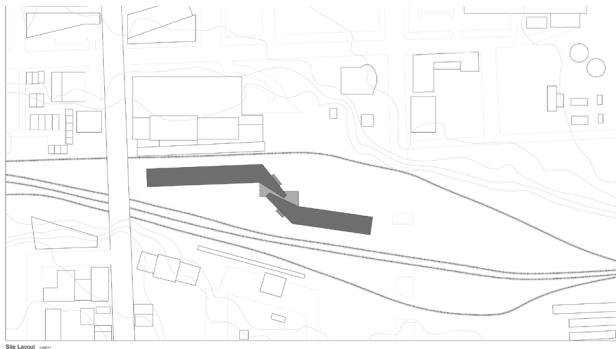
After the semester review, a consistent concern was that the golf course showed no direct architectural relationship with the data center. Thus, after much discussion and consideration, I decided to drop the golf course part of the project and focus on the stronger relationships. Now, **Harvester is born** with a focus on urban agriculture being heated by an underground data center along with the evolution of an inhabitable solar tower.

The first iteration with no golf course focused on trying to connect all the different programs through section. Section remained a key proponent throughout the life of this project. The overall form was not developed at this point and the scale of the greenhouse turned out to be too undersized for the final development.

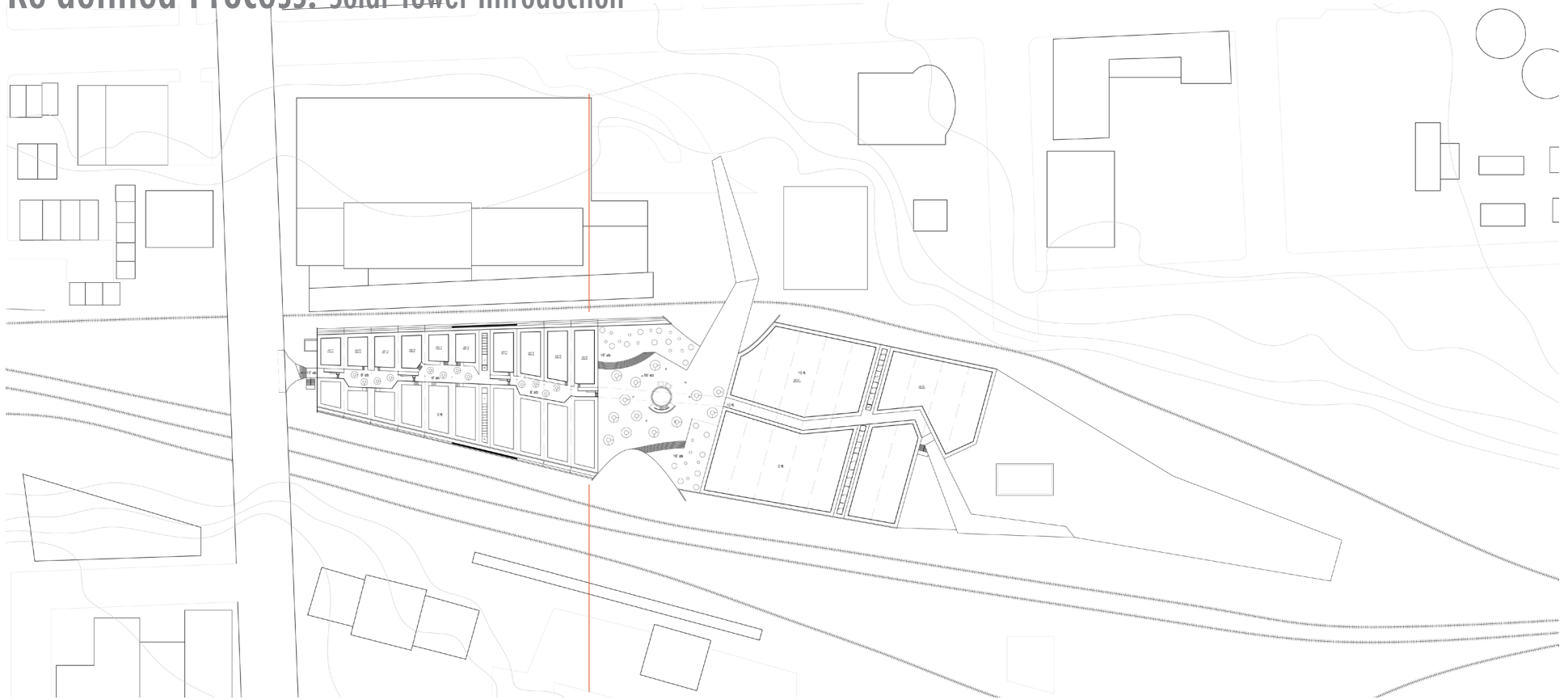
Models developed at this time were investigating the relationship between the ground plane/harvesting plane and underground data center in order to start to visualize how these two components may interact.



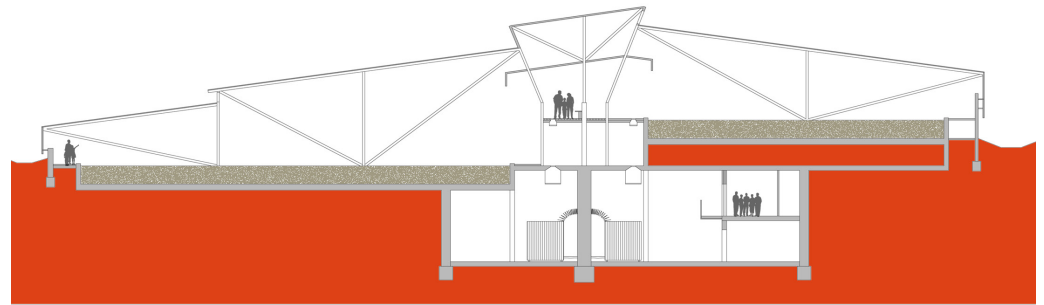
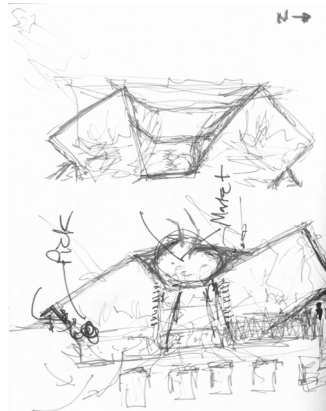
[MANIPULATE LAND
TO EXPOSE PPL TO
LIGHT!]

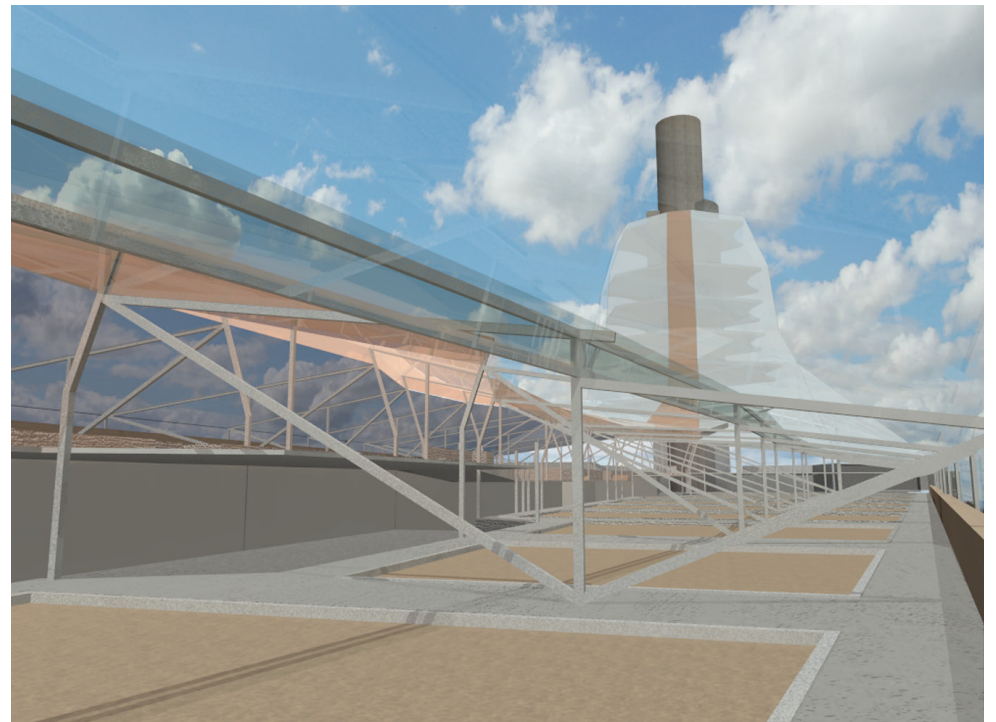
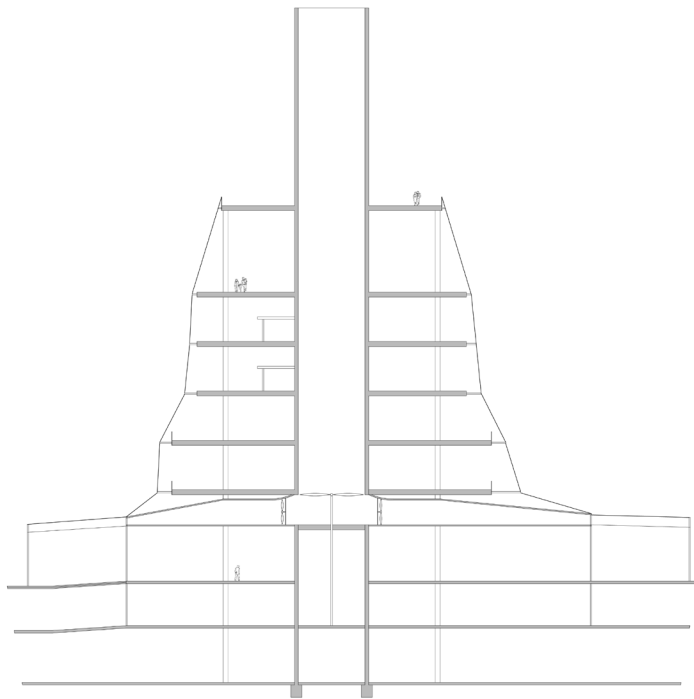
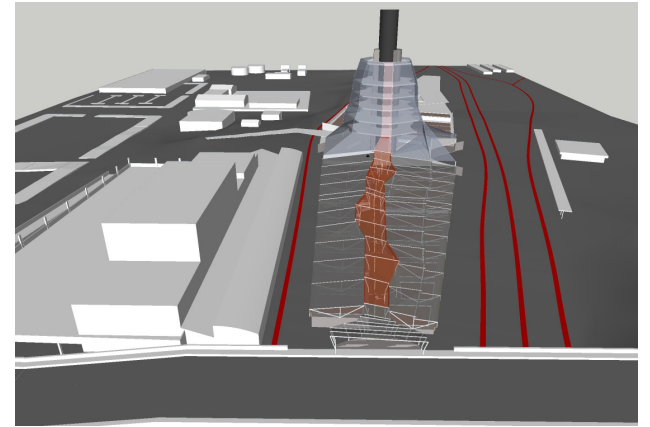
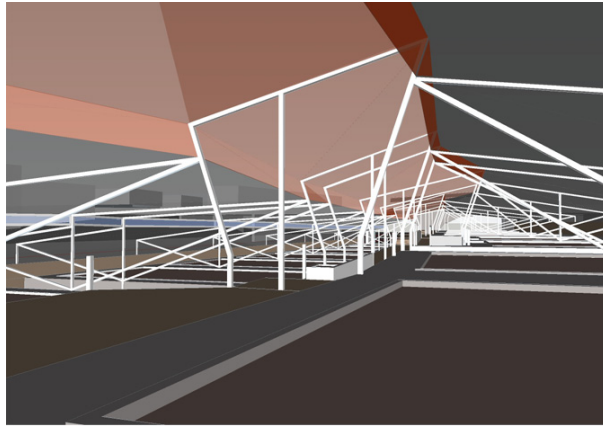
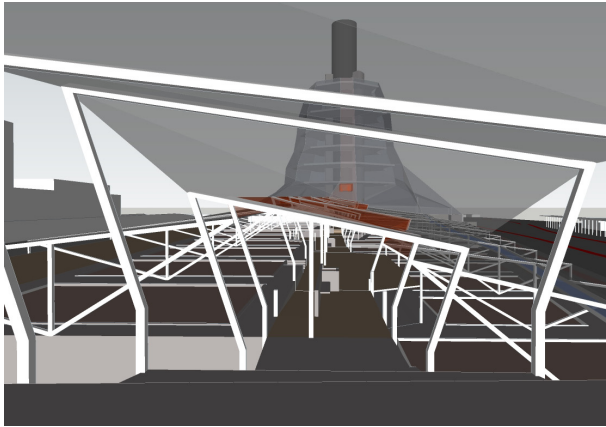


Re-defined Process: Solar Tower Introduction



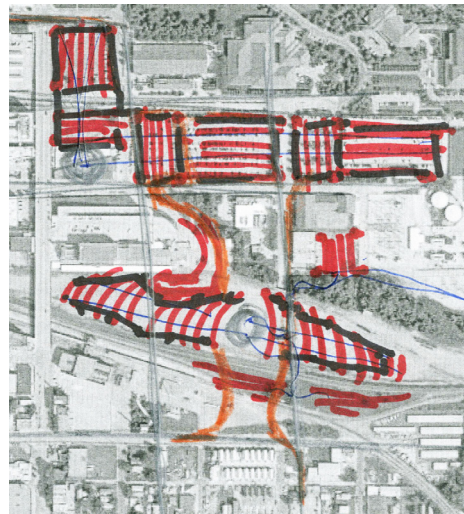
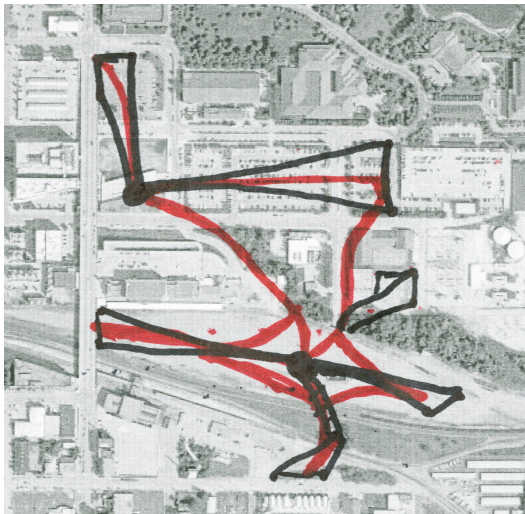
Early in March, the solar tower concept was introduced into the full system. This iteration shows a much stouter tower than the final design and a greenhouse structure that ended up being a little too over-bearing. Some of the final design ideas were starting to be developed at this point but needed much more development.



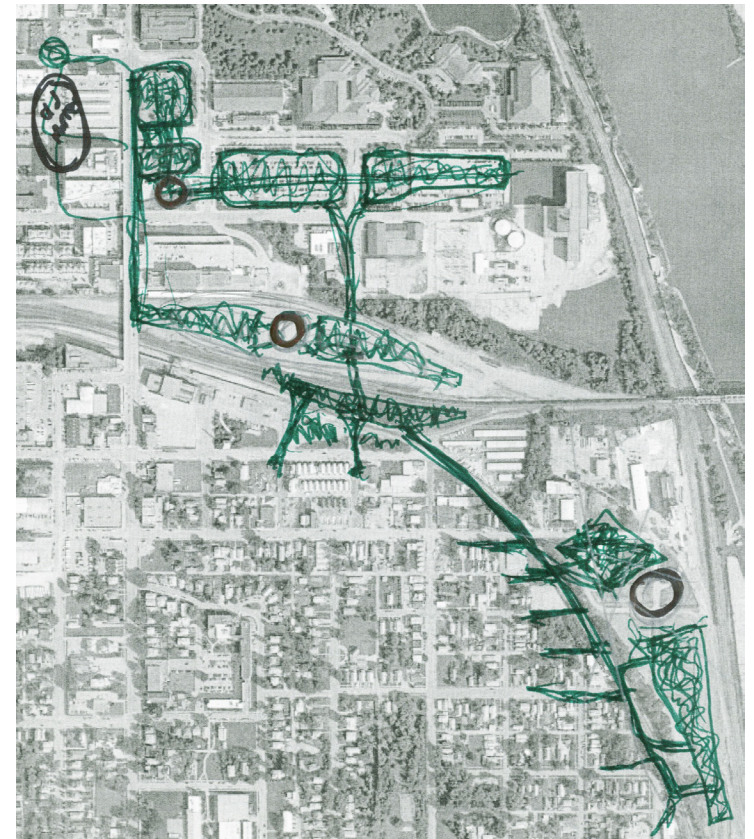


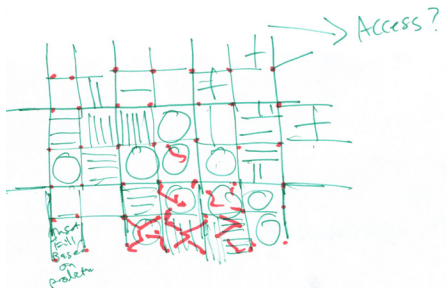
Re-defined Process: "Bigger Picture" Site Studies

After reviews and discussions in early March, it was clear that the idea and concepts had great potential. What the project really needed was a push for growth, along with a more zoomed out point of view. Although some of the relationships were beginning to gel, I needed to try and conceive a way for this project to expand and really display its purpose.

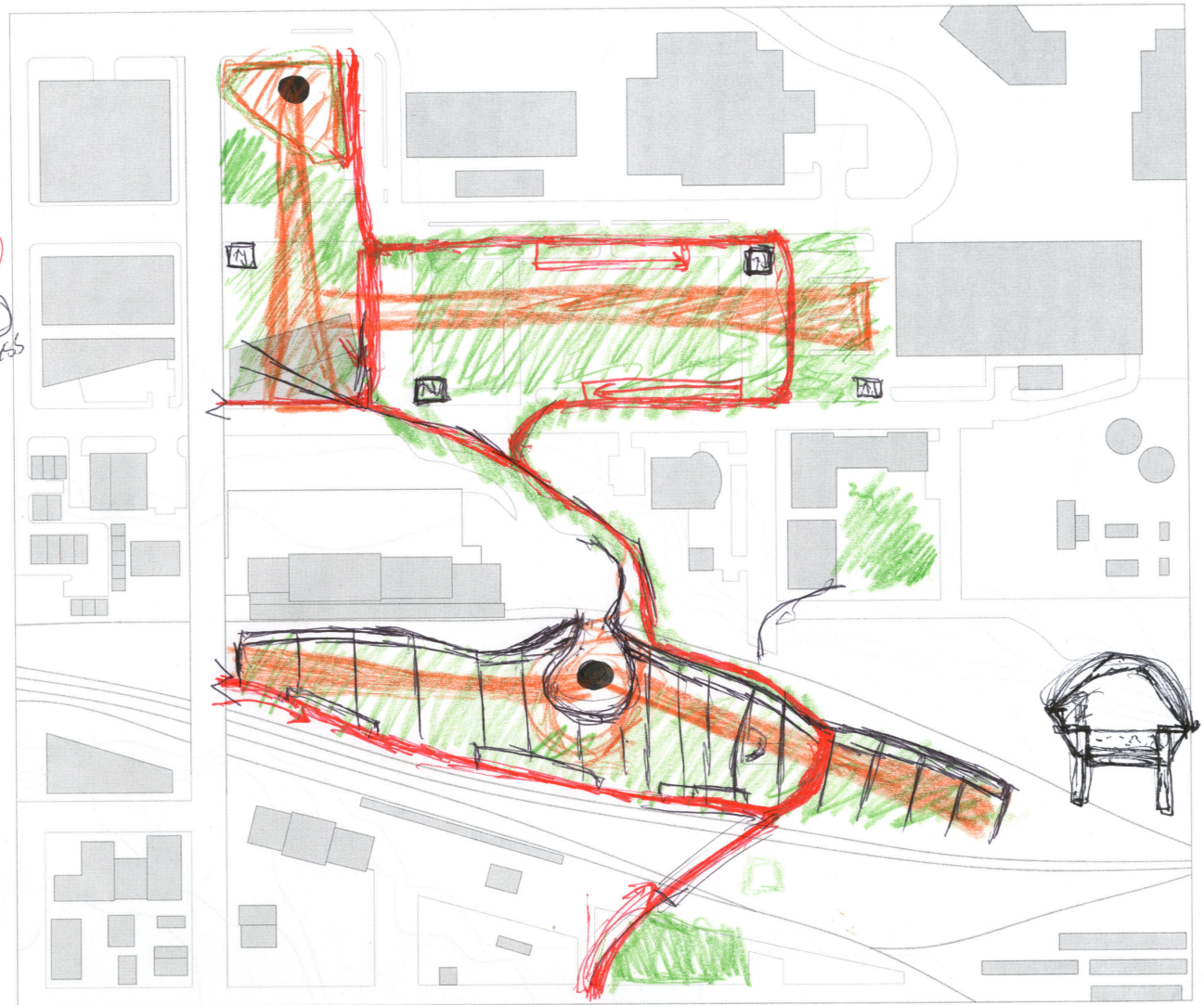


These site studies start to explore ways that the project spreads from the main industrial defunct, "hub" site to other potential "satellites." Anything from computational organization to examining various worldwide agriculture pattern were methods used in order to search for a way to keep this growth somehow connected and controlled.



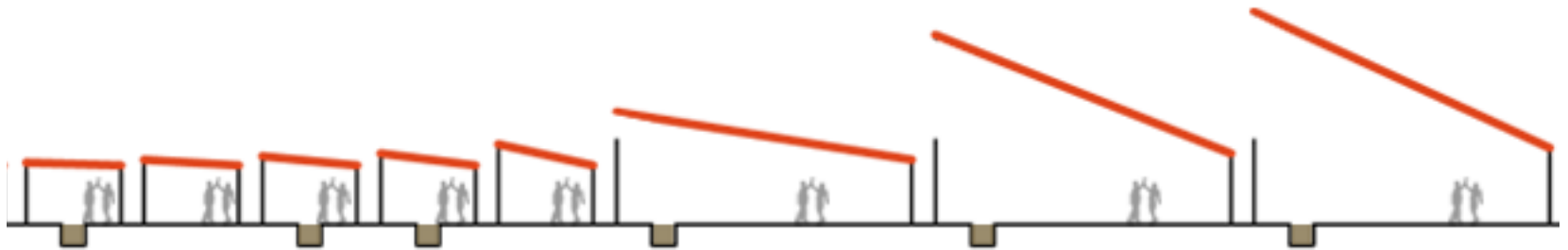
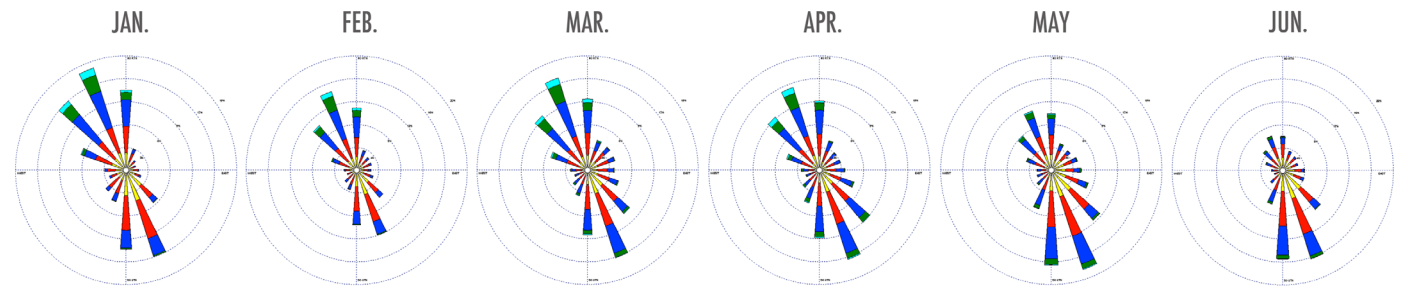


- Pub.
 - priv.
 Access



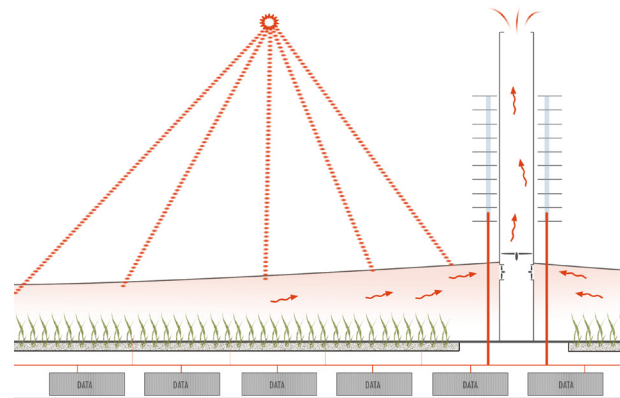
Design Concepts

Market Scoop: Reacting to the wind patterns and time of year when more natural ventilation will be needed. The structure should open up at certain points of emphasis in order to enhance natural wind ventilation and circulation.

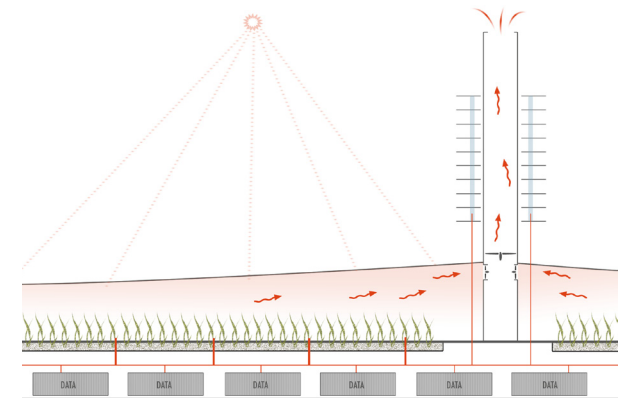


Mutualistic/Re-directed Heat:
The data containers heat the greenhouse and tower throughout the year. Depending on the season, heat can be re-directed to where it will be most beneficial.

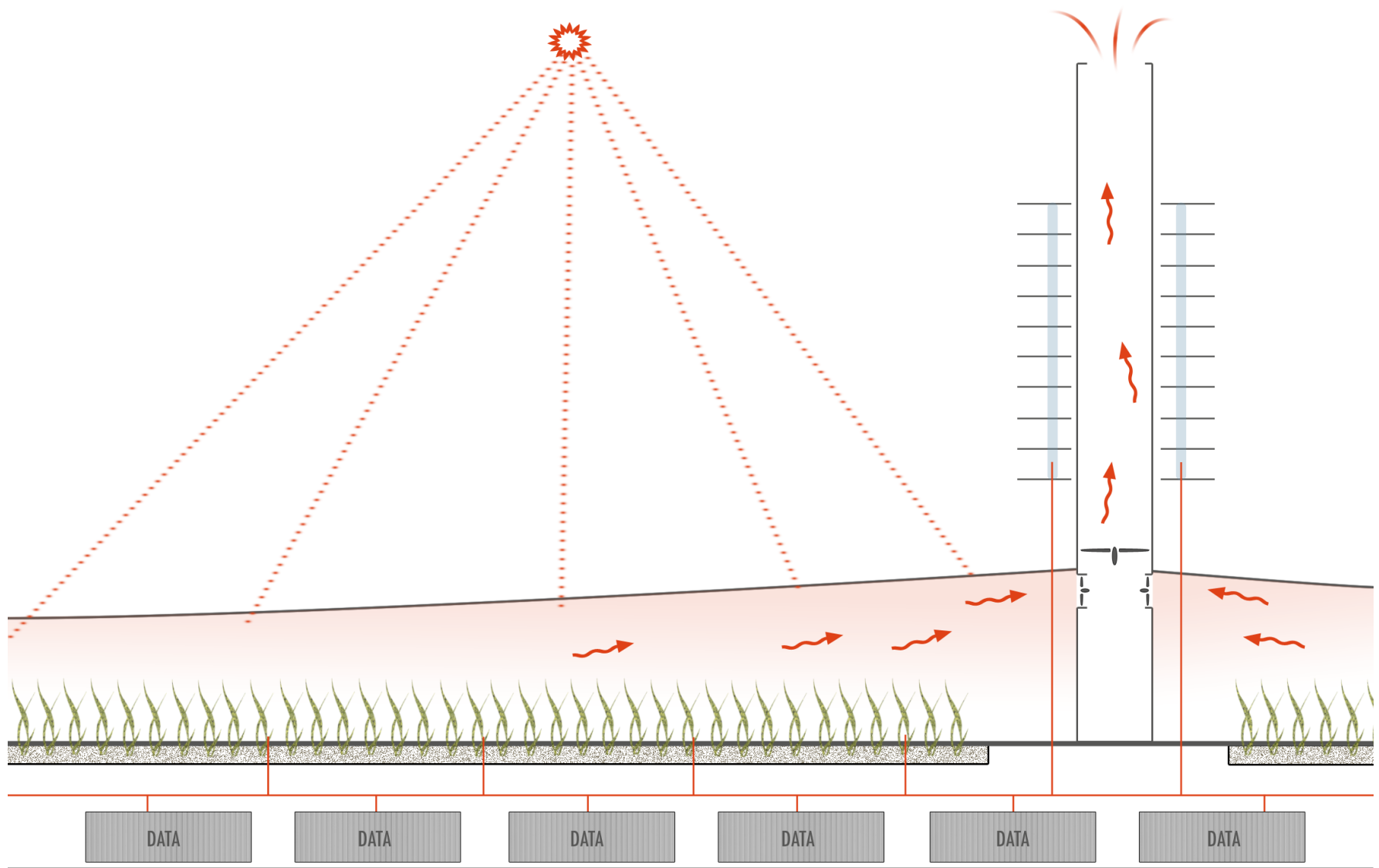
Summer:



Winter:



Spring/Fall:



Design Concepts - Utilizing the Containers as a **HEAT** Source

1 container has 22 server racks
1 server rack can hold 50 servers
1 server averages 250 watts of electricity
1 watt = 3.41 btu's

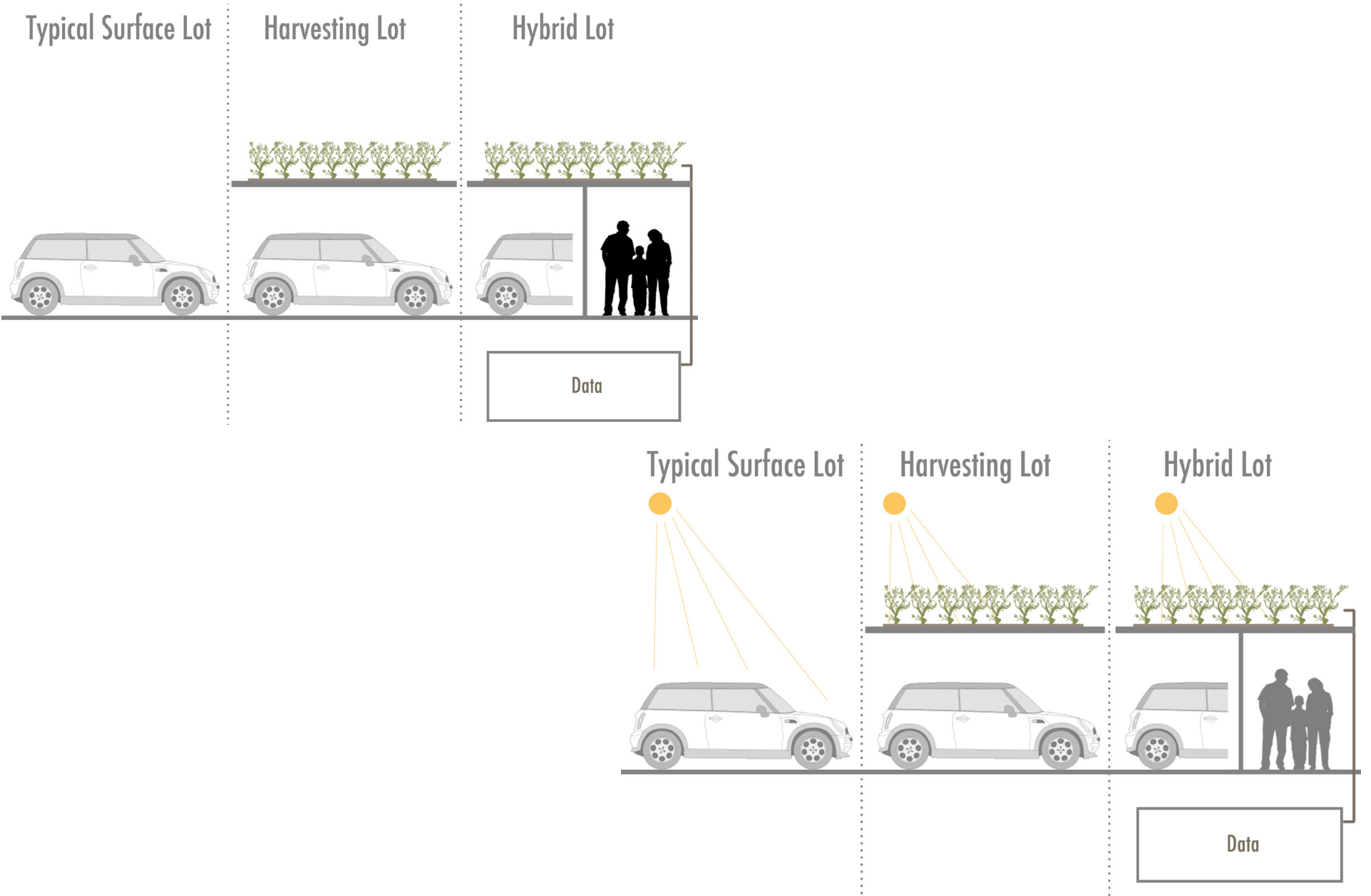
22 racks x 50 servers = 1,100 servers
1,100 servers x 250 watts/server =

2,750,000 watts/container
x 3.41 btu's/watt =

937,750 btu's of heat per container!

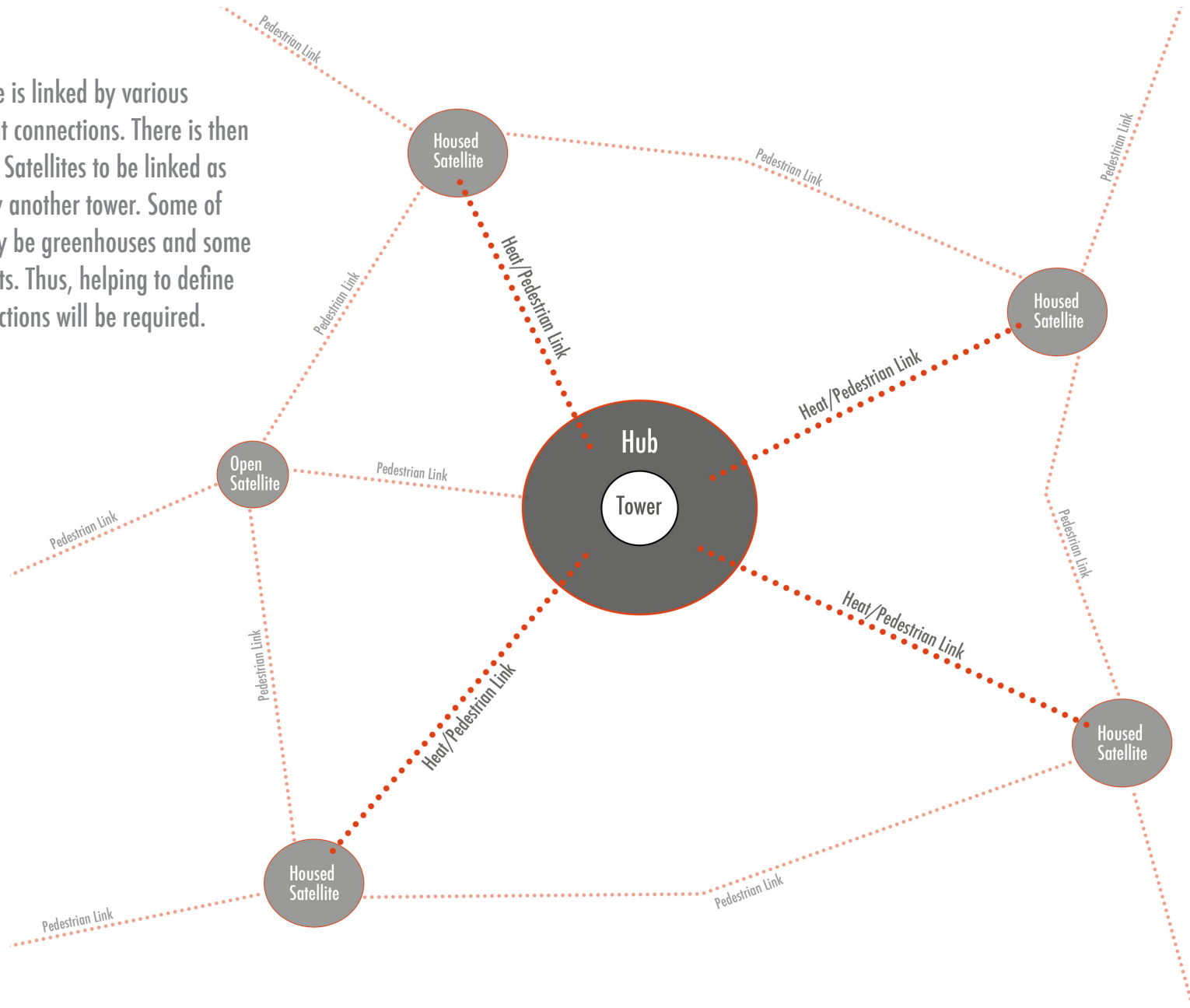


Design Concepts - Satellite Surface Lot Transformation



Design Concepts - General Hub to Satellite Relationship

The central Hub site is linked by various pedestrian and heat connections. There is then opportunity for the Satellites to be linked as well and eventually another tower. Some of these Satellites may be greenhouses and some may be ground plots. Thus, helping to define what type of connections will be required.



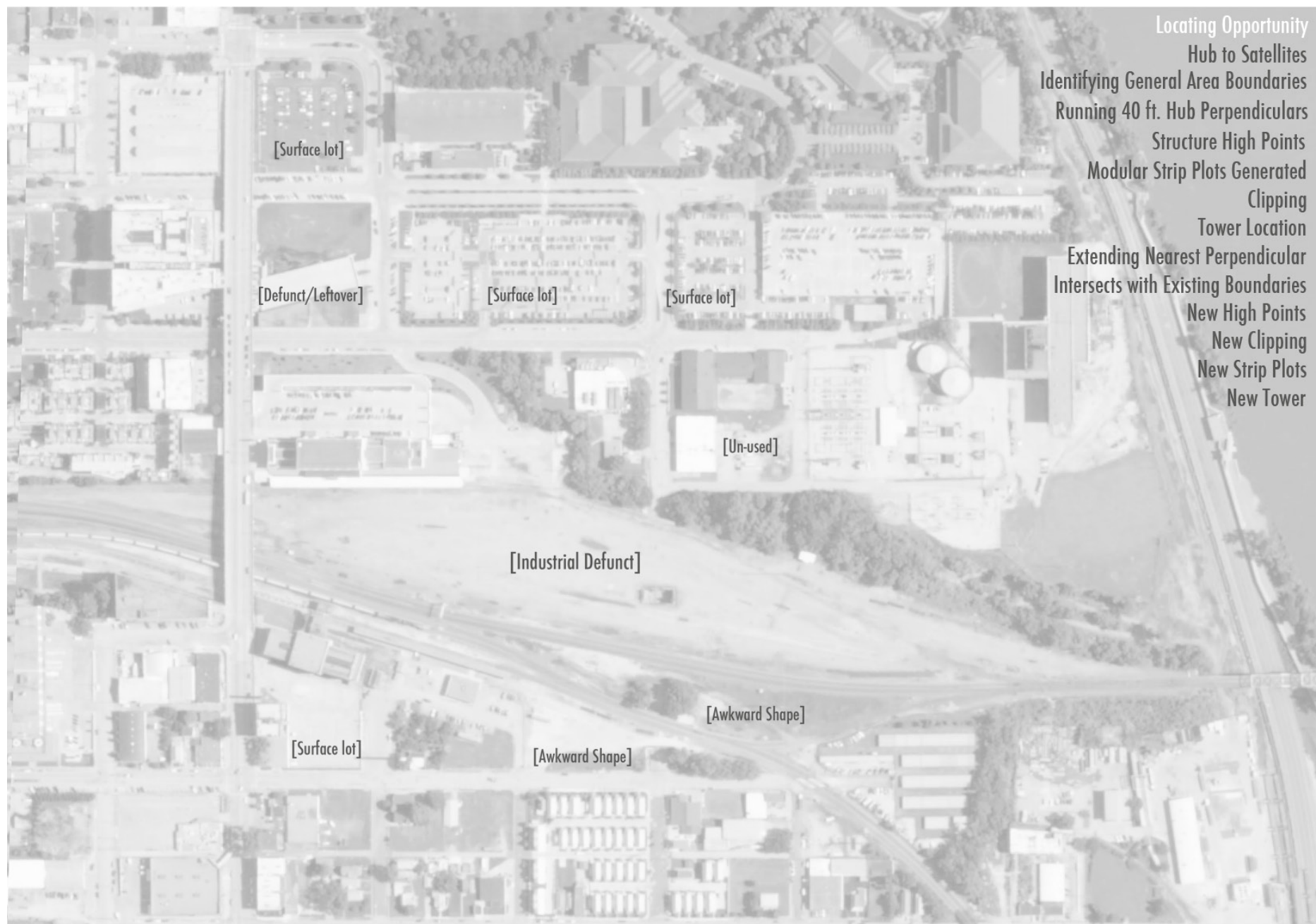
HUB Site Selection:

- ## SATELLITE Selection:

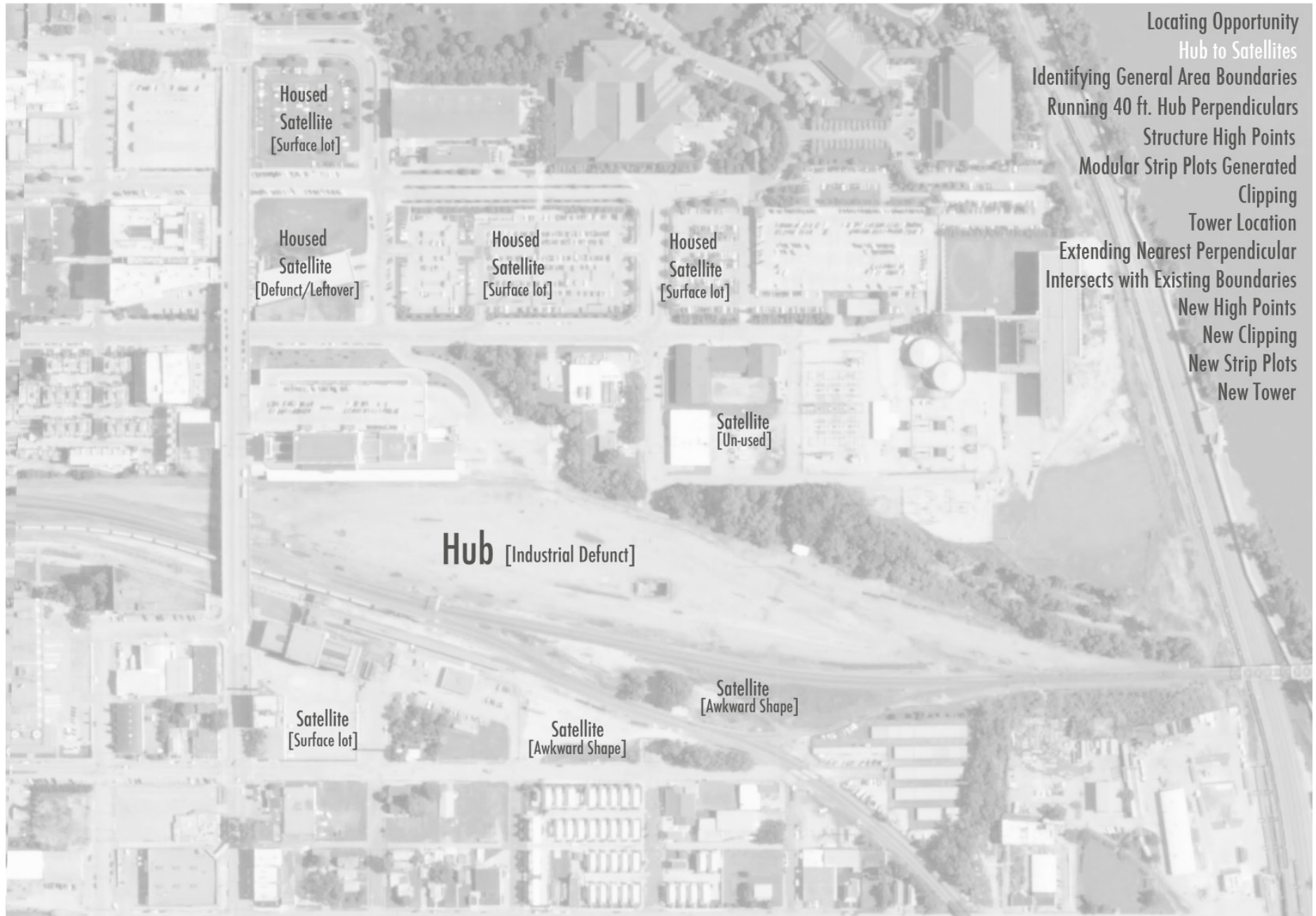
- ## Schematic - Design Concepts

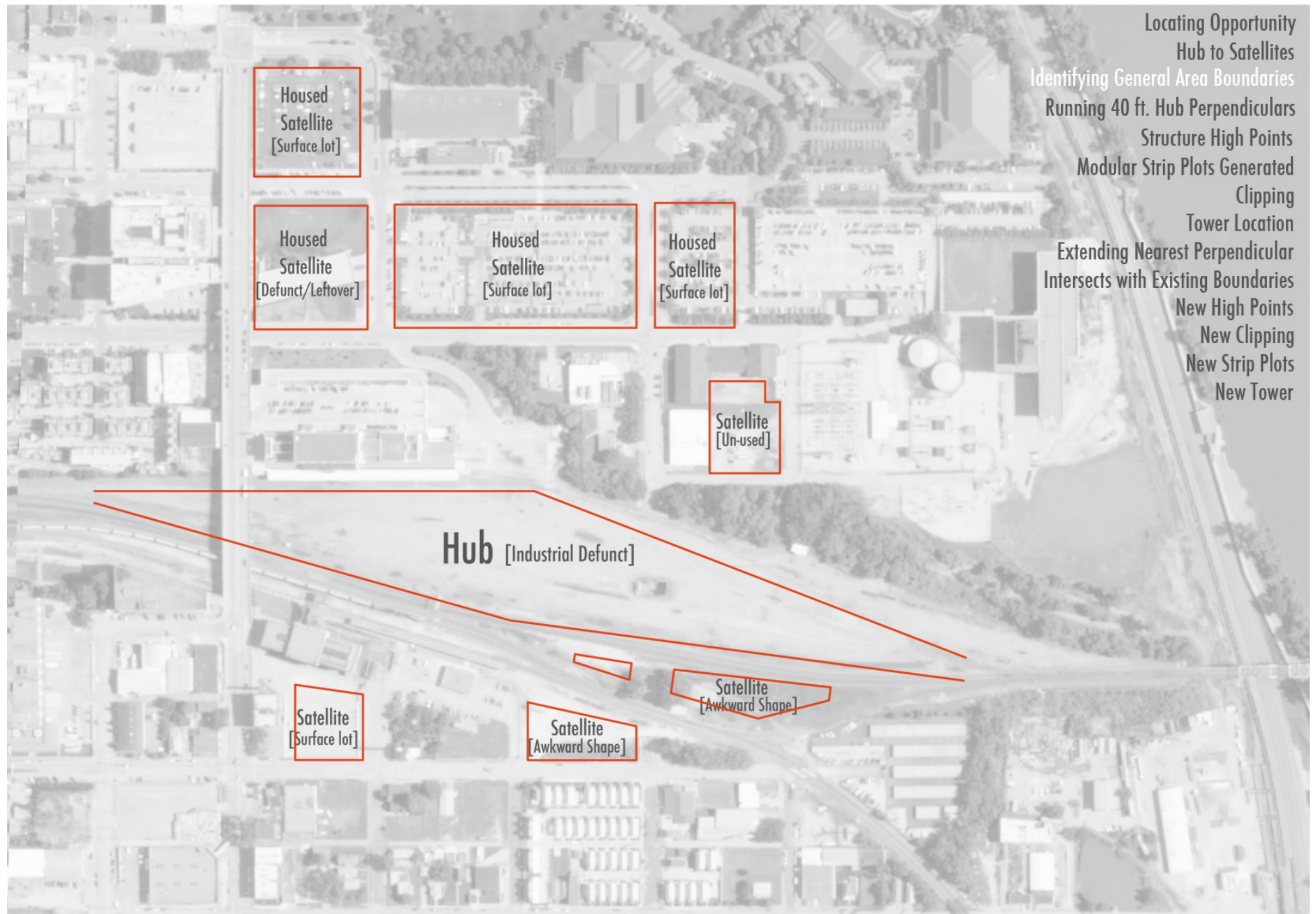
Site Specific Growth System

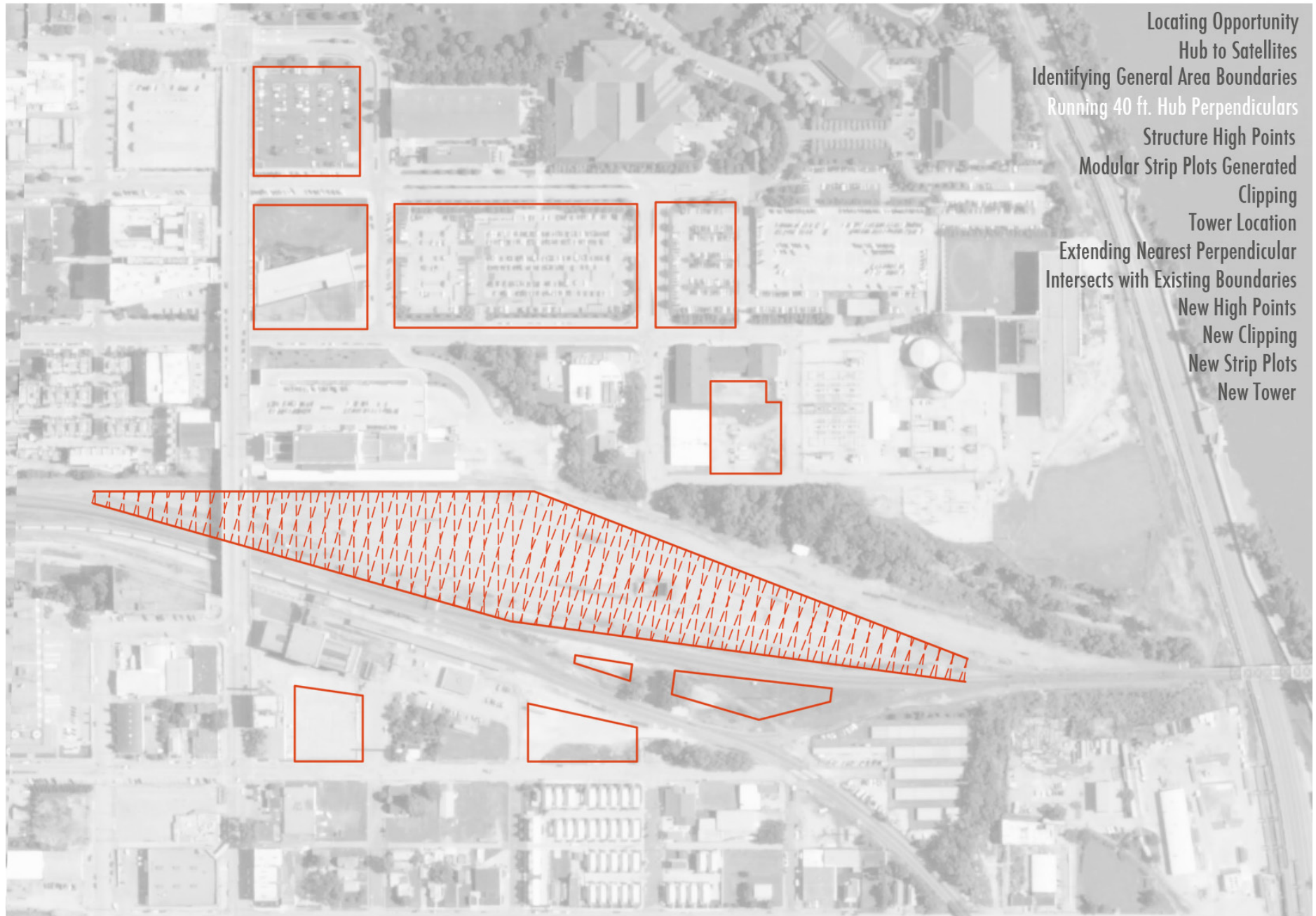
This sample growth system for the selected site was developed in order to try and establish geometric relationships between the Hub site and the various Satellite sites. The Hub acts as a take off point with its specific lines and then that extends out into the Satellite space, which helps generate the various plot and structure layouts.



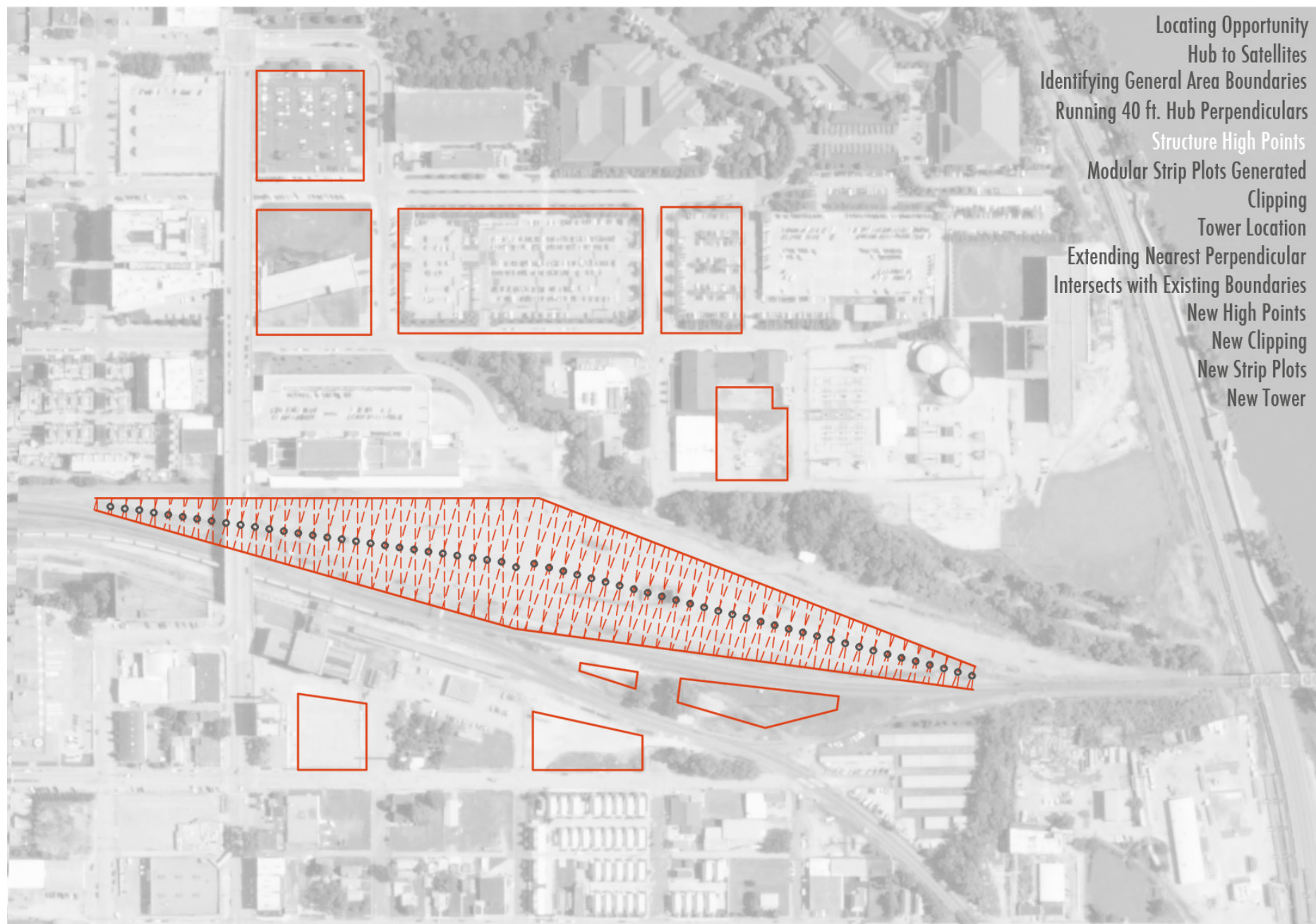
Locating Opportunity
Hub to Satellites
Identifying General Area Boundaries
Running 40 ft. Hub Perpendiculars
Structure High Points
Modular Strip Plots Generated
Clipping
Tower Location
Extending Nearest Perpendicular
Intersects with Existing Boundaries
New High Points
New Clipping
New Strip Plots
New Tower



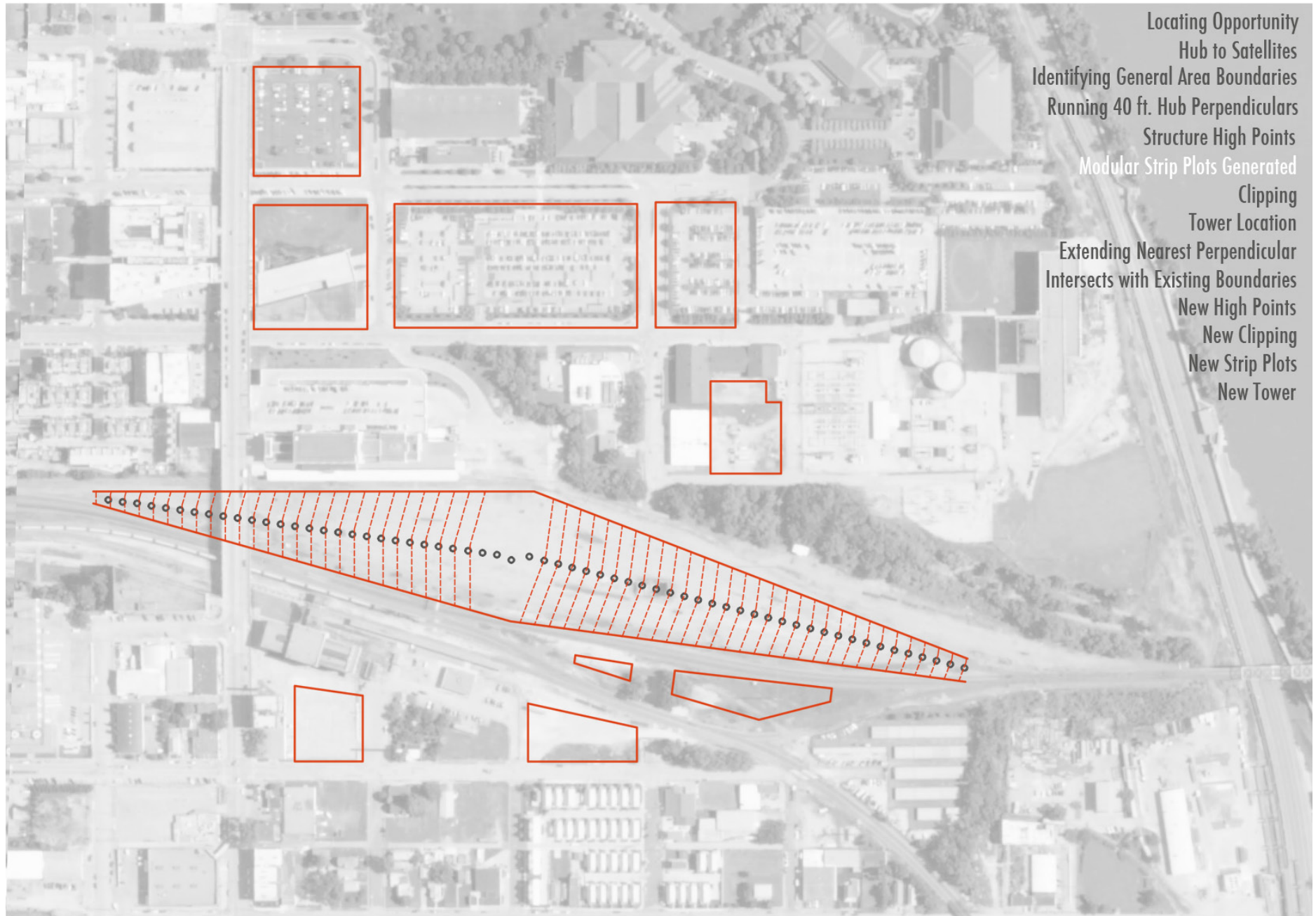


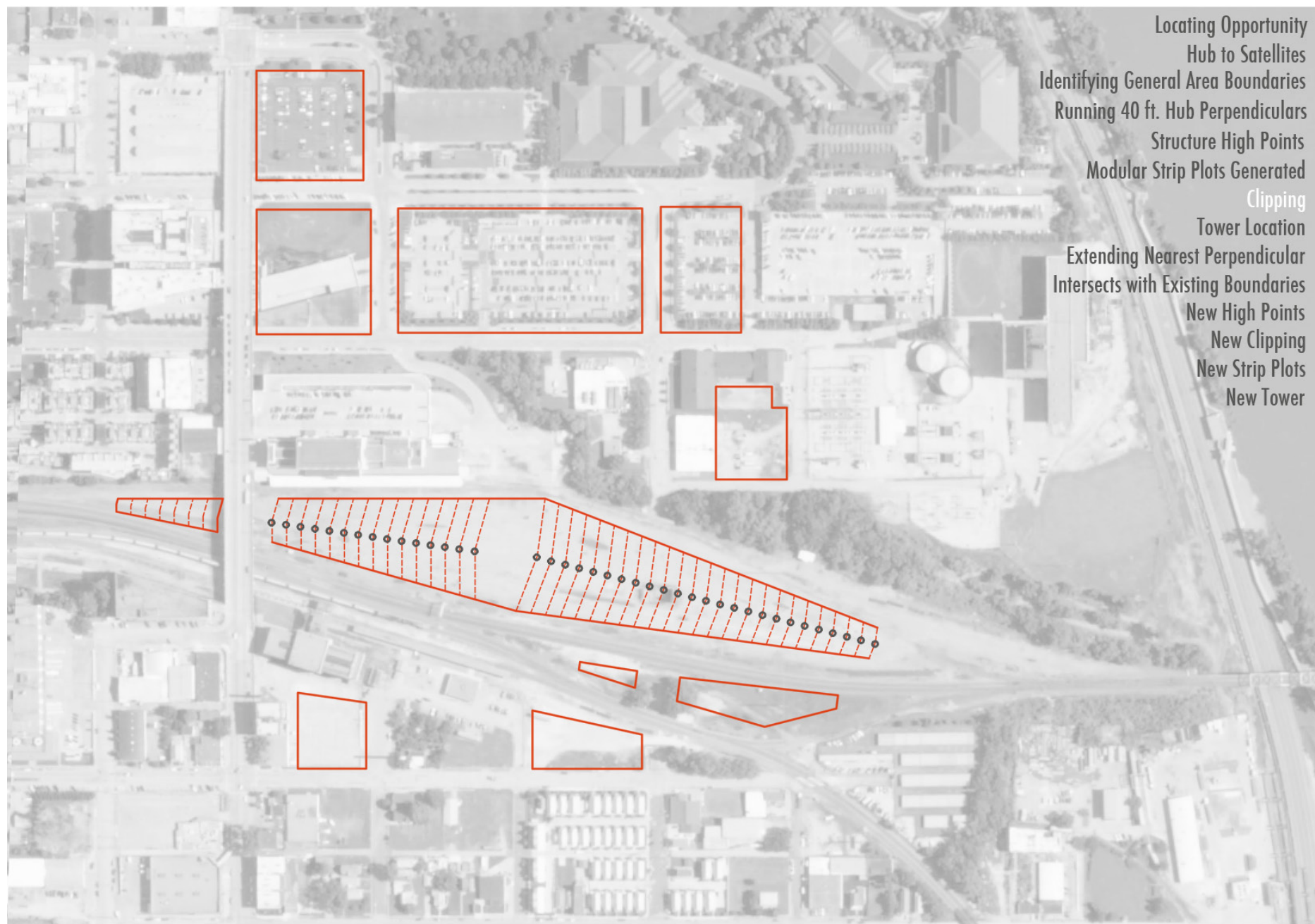


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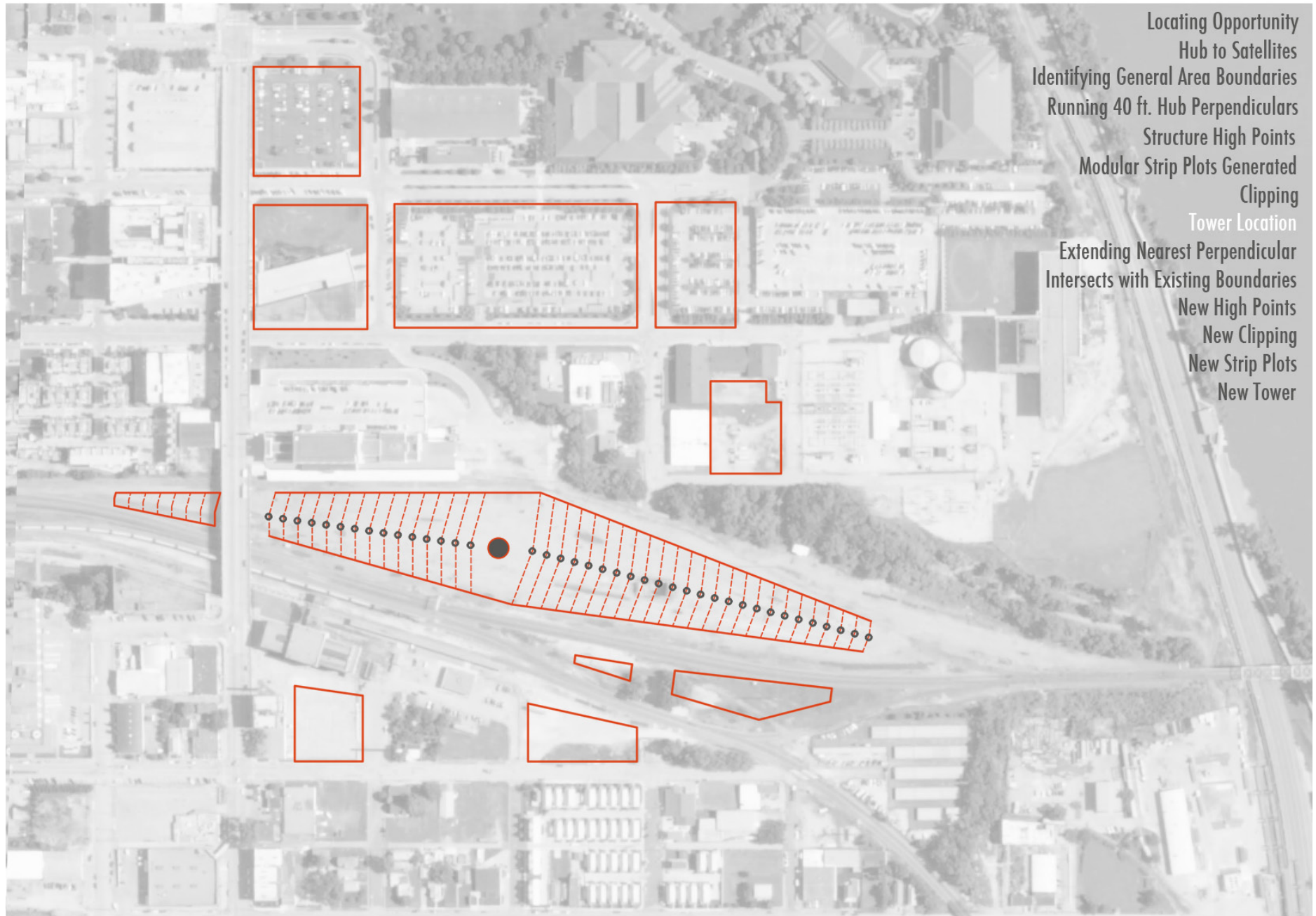


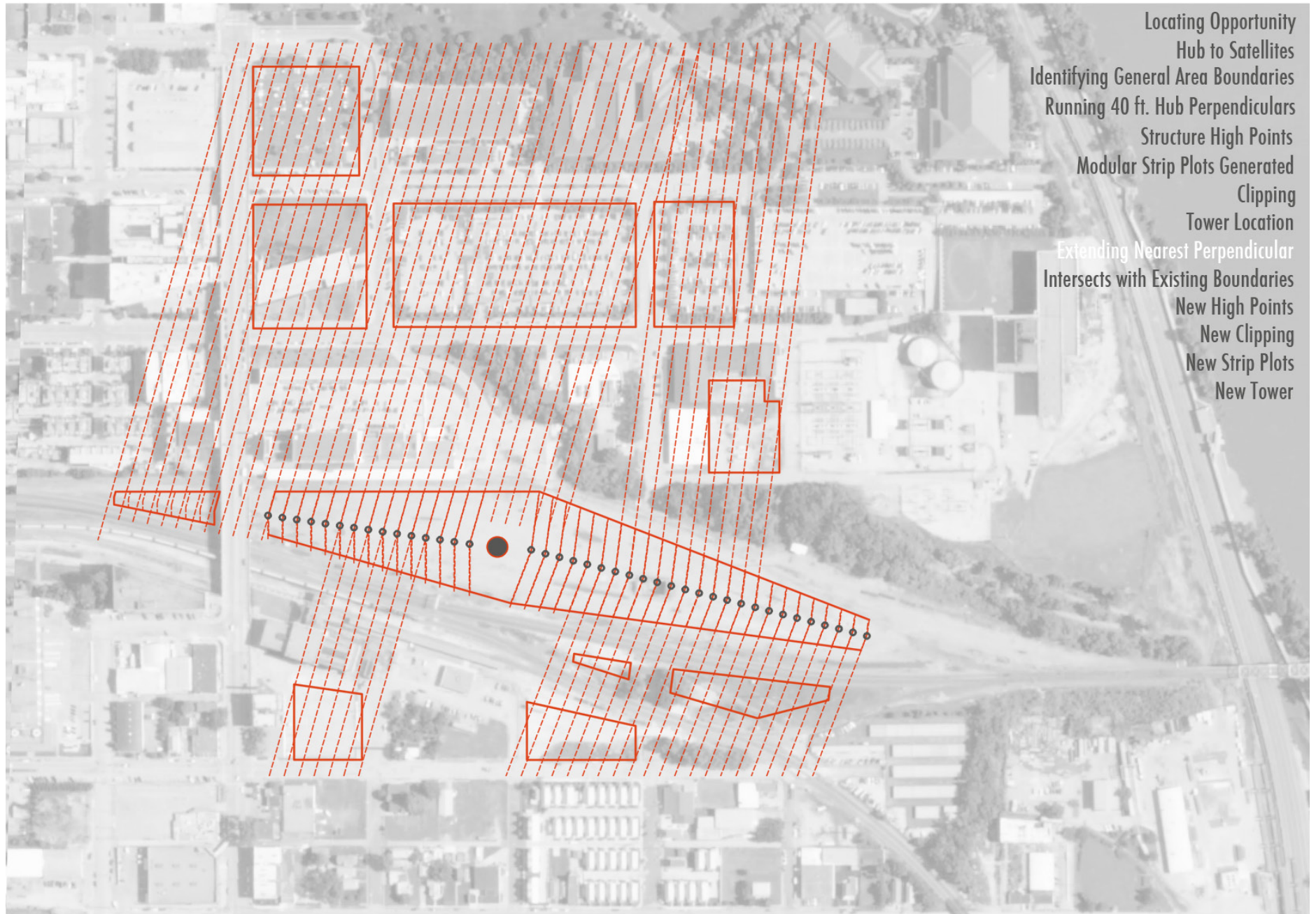
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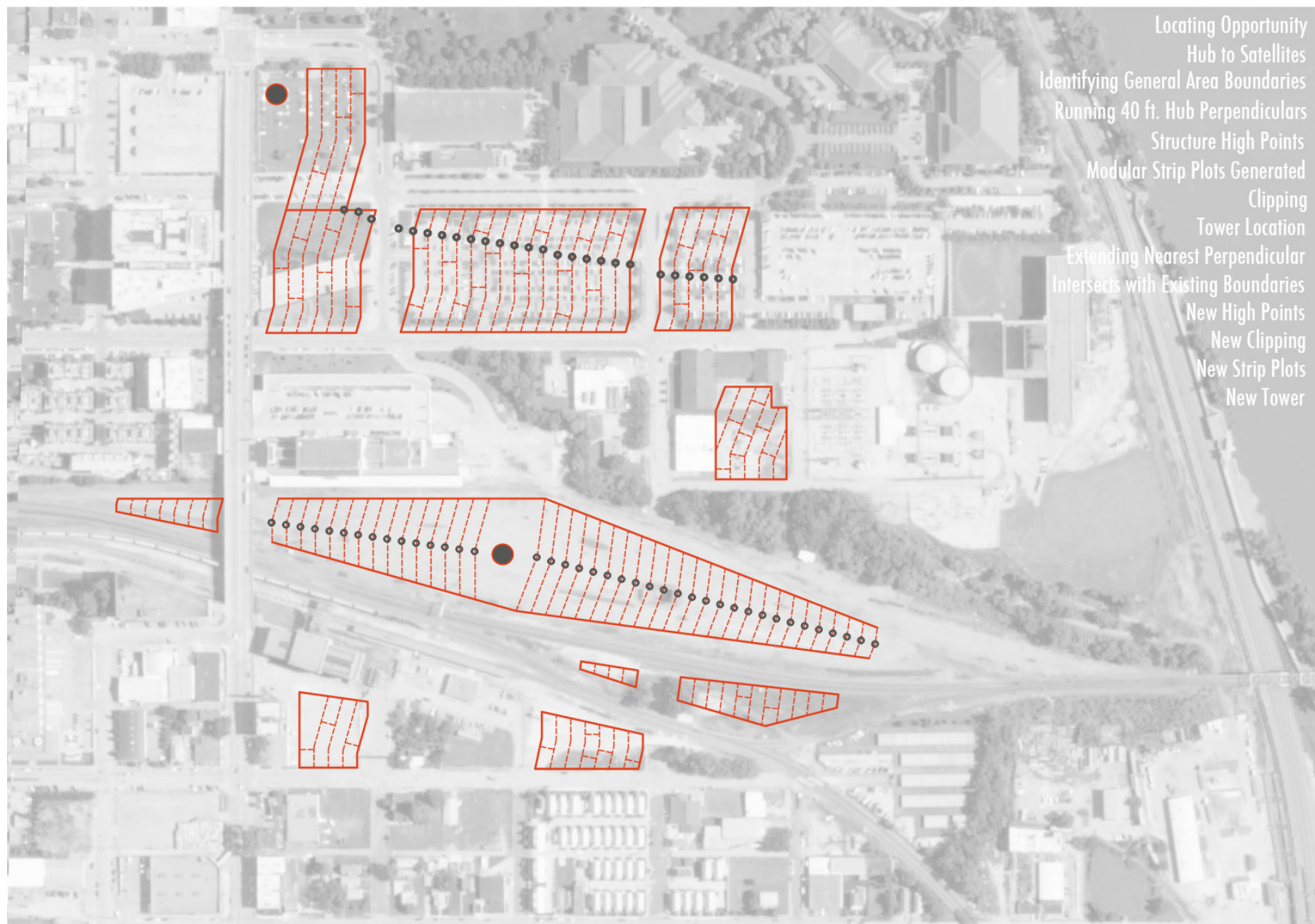
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Project Characteristics:

Solar Tower Height: 800 ft.

Occupied Height: 650 ft.

Total Building Square Footage: 1.15 million sf.

- Data Center: 83,500 sf.

 - 30 containers with a total capacity for 60,000 servers

- Basement/Ag Storage: 36,500 sf.

- Main Lobby/Market Place: 48,500 sf.

- Office Block 1: 80,000 sf.

- Office Block 2: 124,000 sf.

- Agri-Hotel: 168,100 sf.

- Residence Block 1: 211,500 sf.

- Residence Block 2: 150,000 sf.

- Look-Out/Restaurants: 50,000 sf.

- Support Space: 36,680 sf.

- Green Voids: 150,000 sf.

Average Data Heat Produced at Capacity:

28,132,500 btu's

Approximate Heat Output Required:

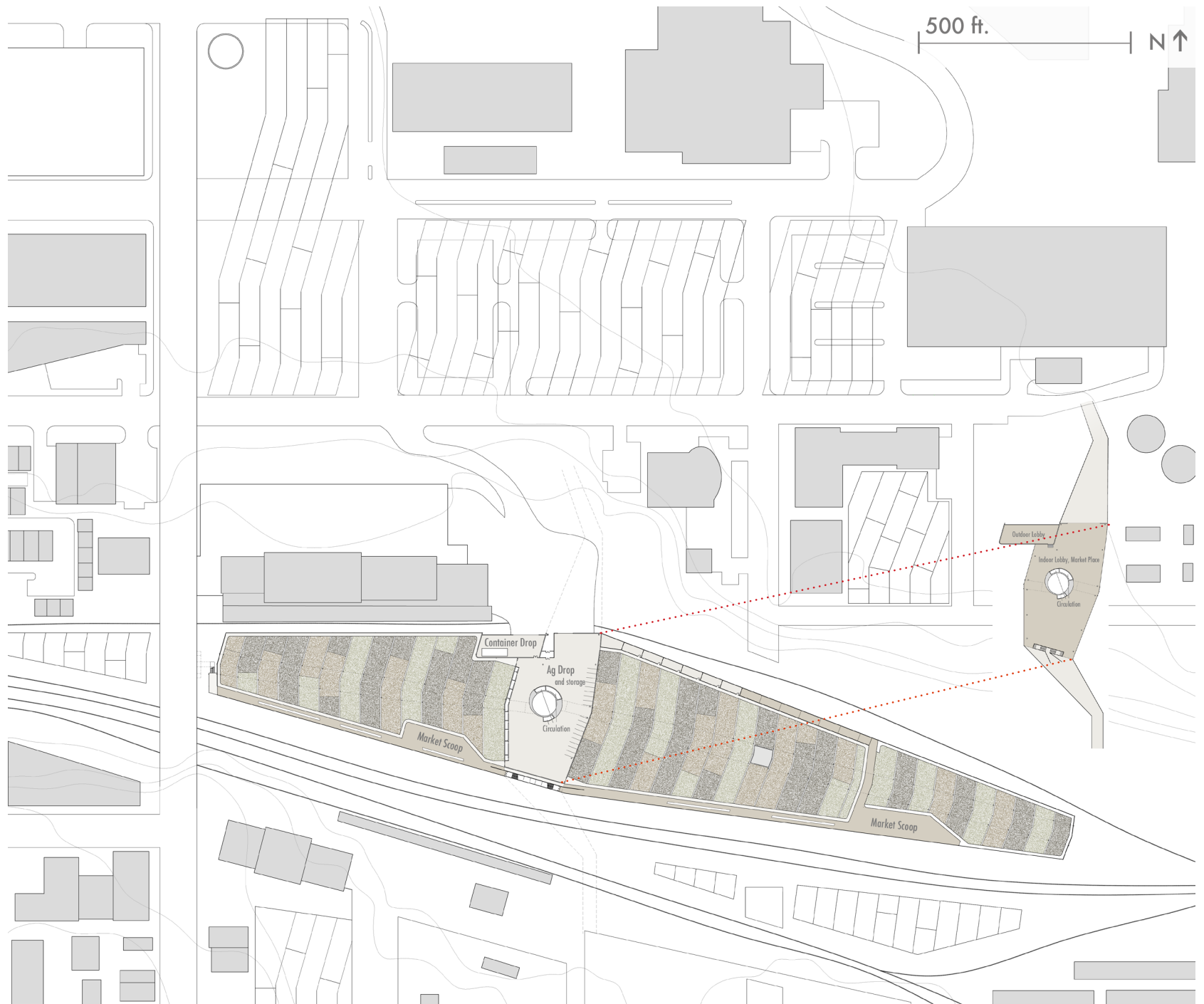
30,000,000 btu's

Total Acres farmed for suggested Hub/

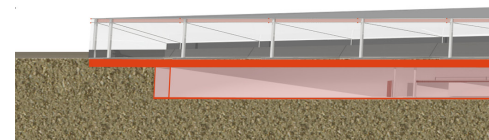
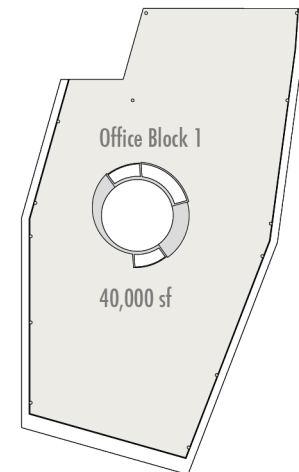
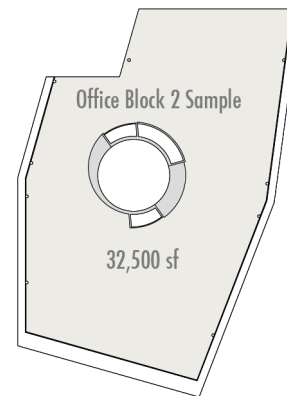
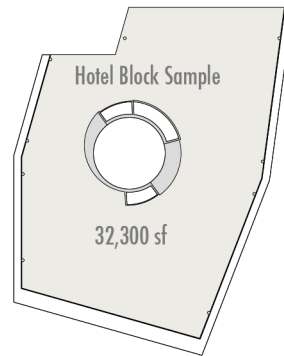
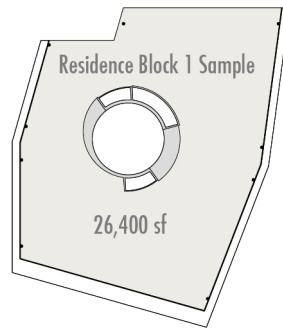
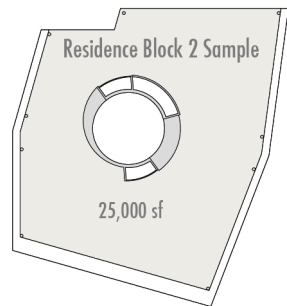
Satellite Series 1: 19 (820,000 sf)

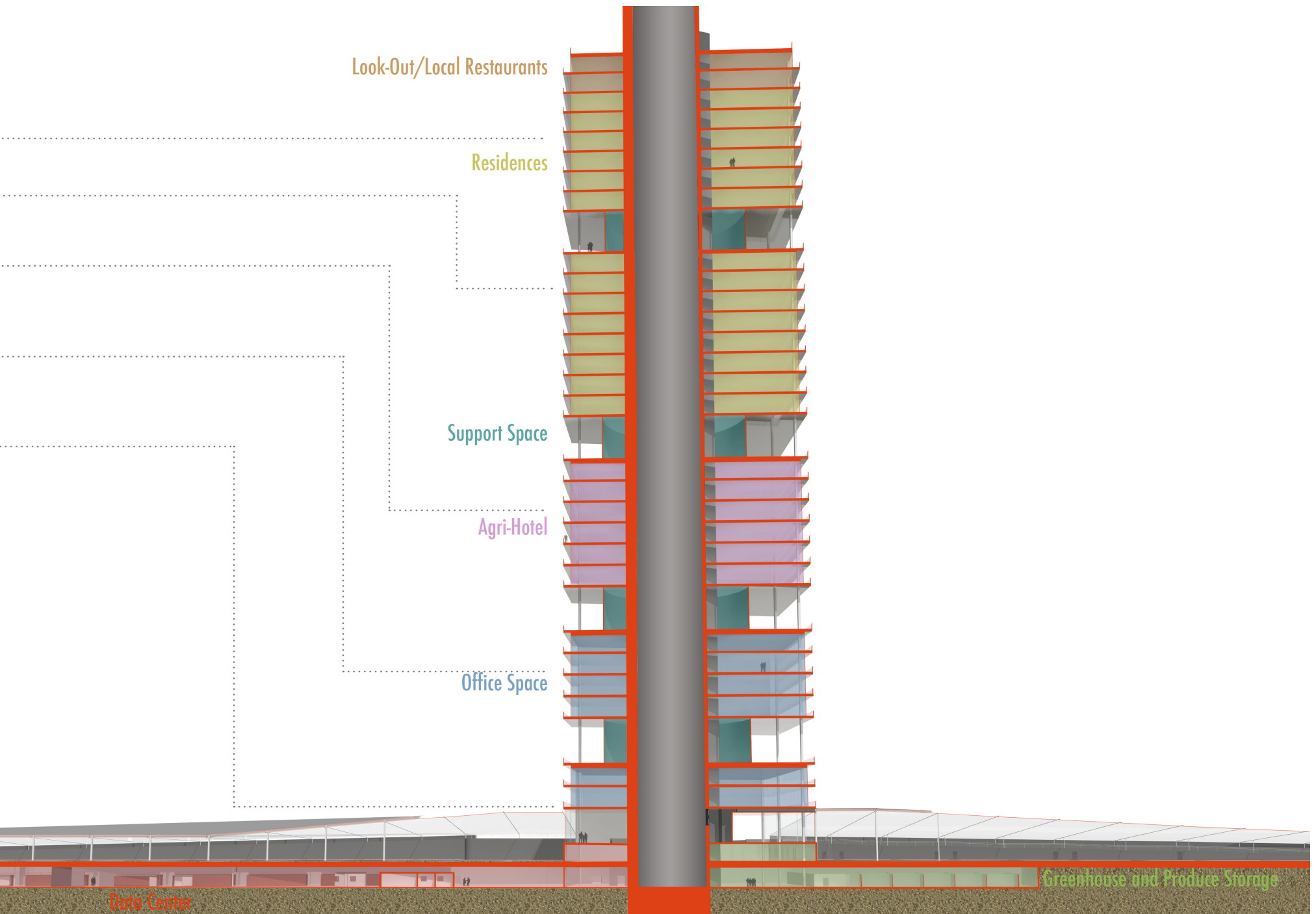
Hub Only Acres Farmed: 5.5 (240,000 sf.)



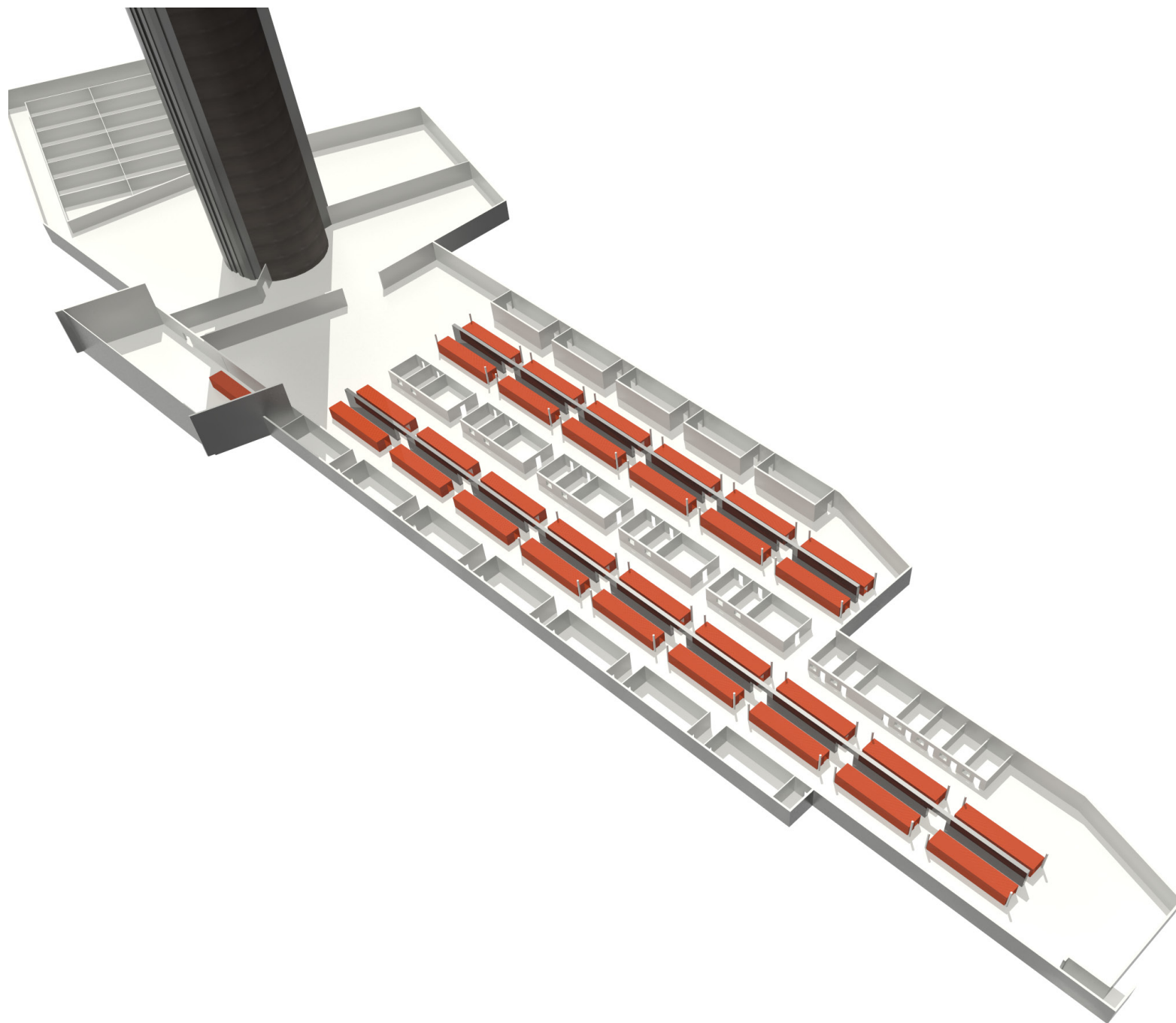


Rendered Site Plan - Market Lobby and Ground Level Plan

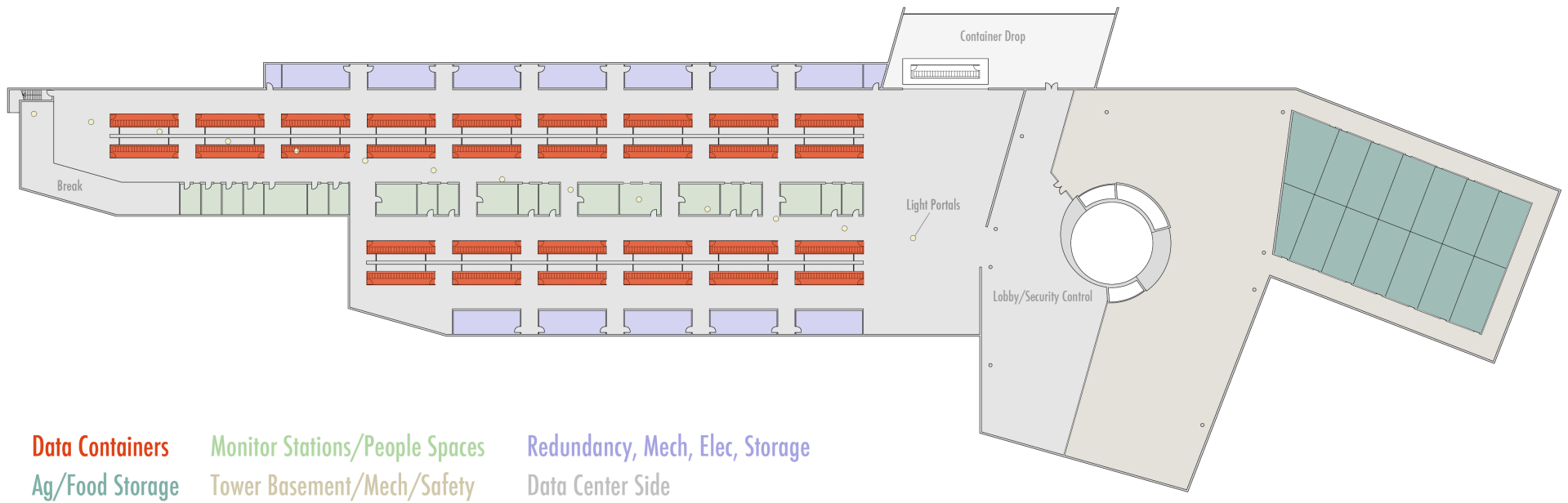


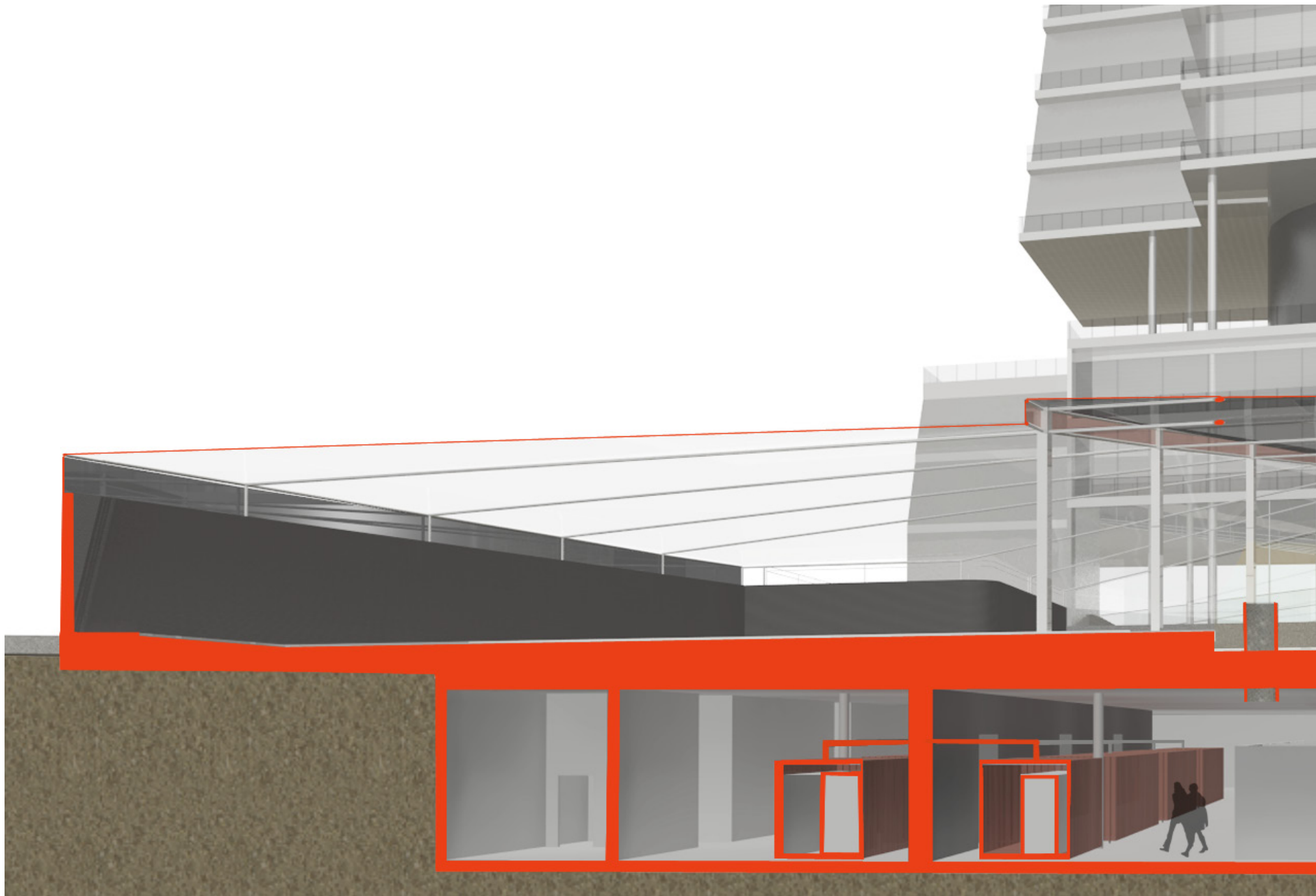


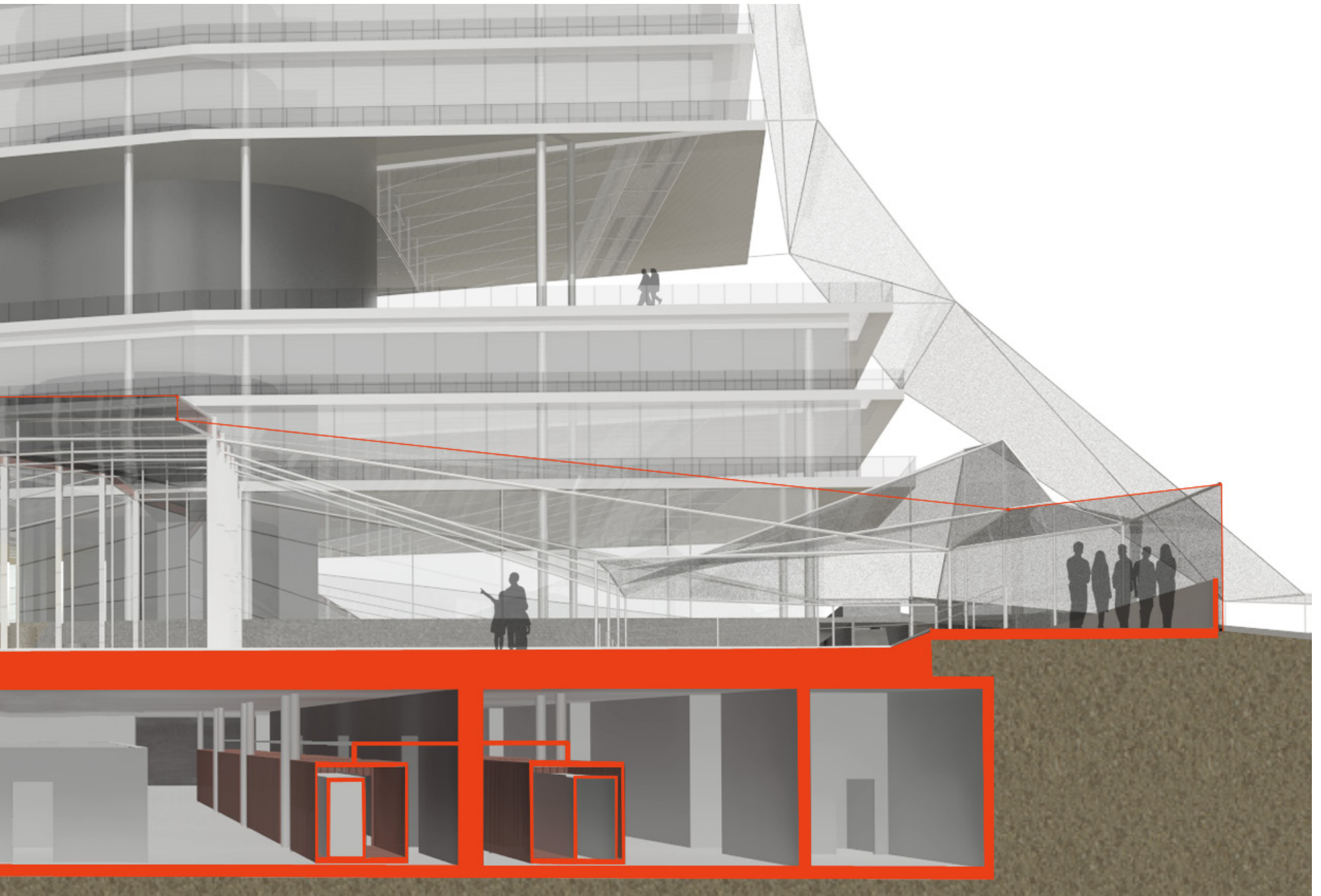
Longitudinal Section with Corresponding Tower Sample Floor Plans



100 ft. N ↑







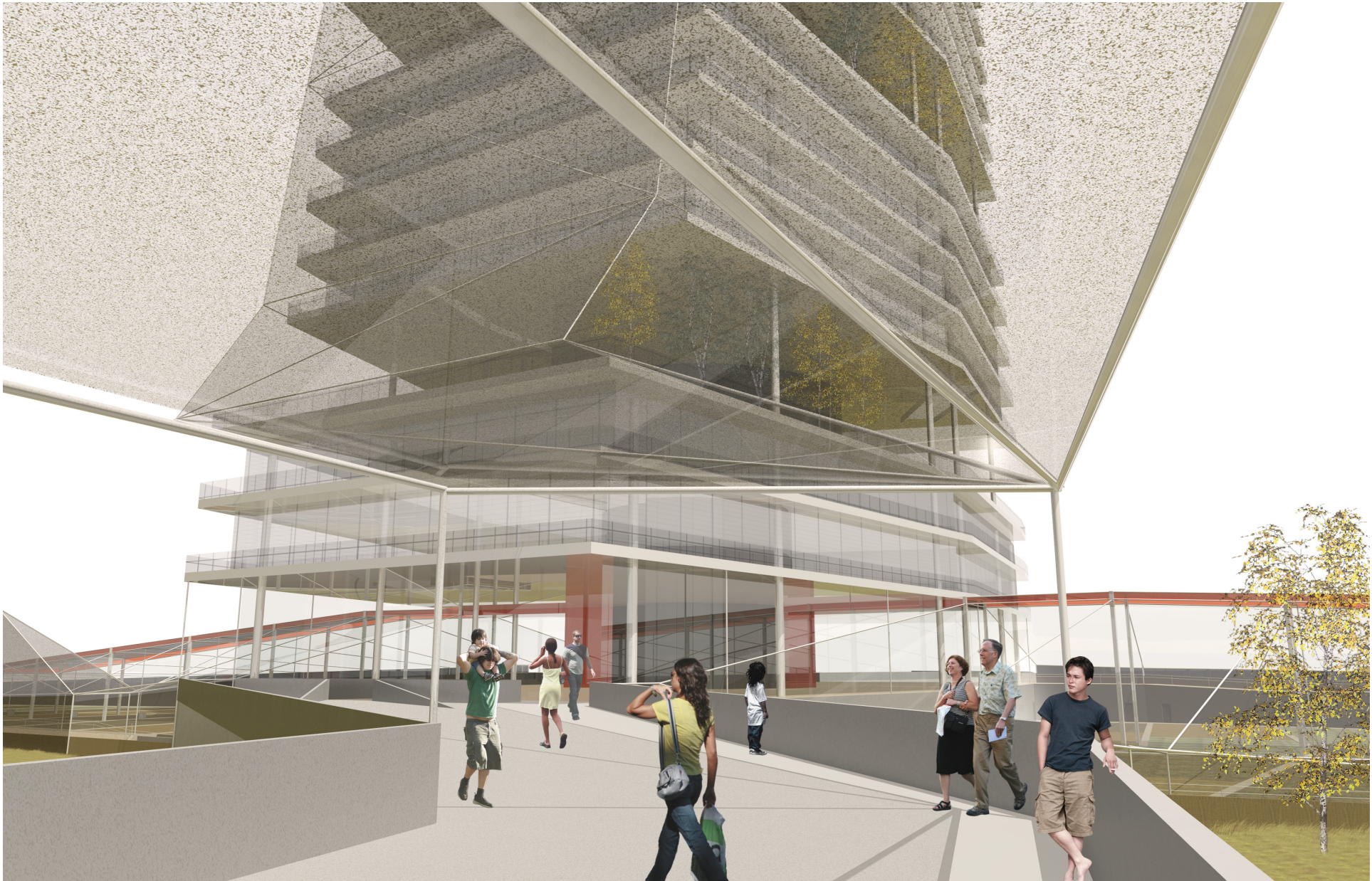
Transverse Section Through West Hub Greenhouse





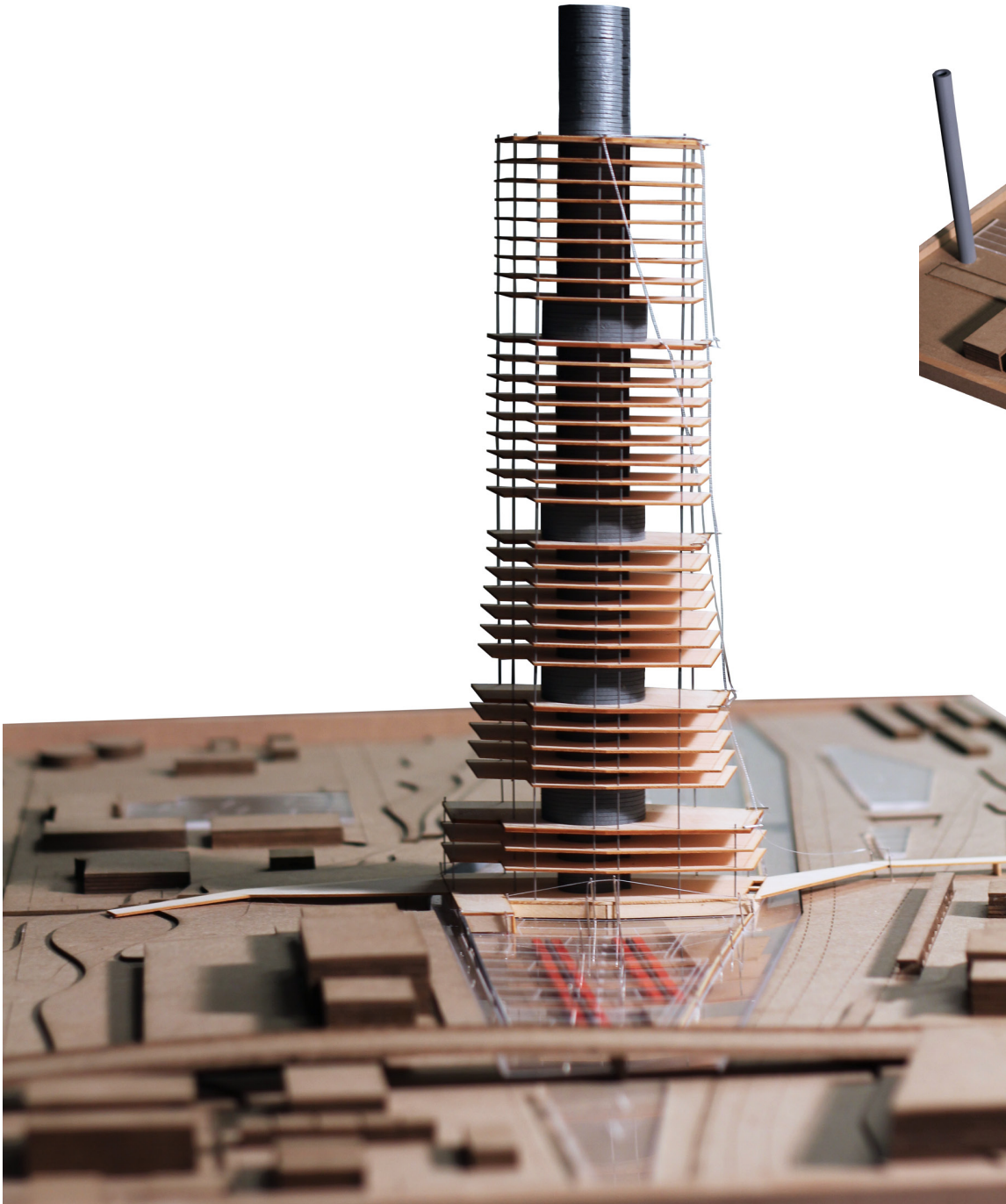
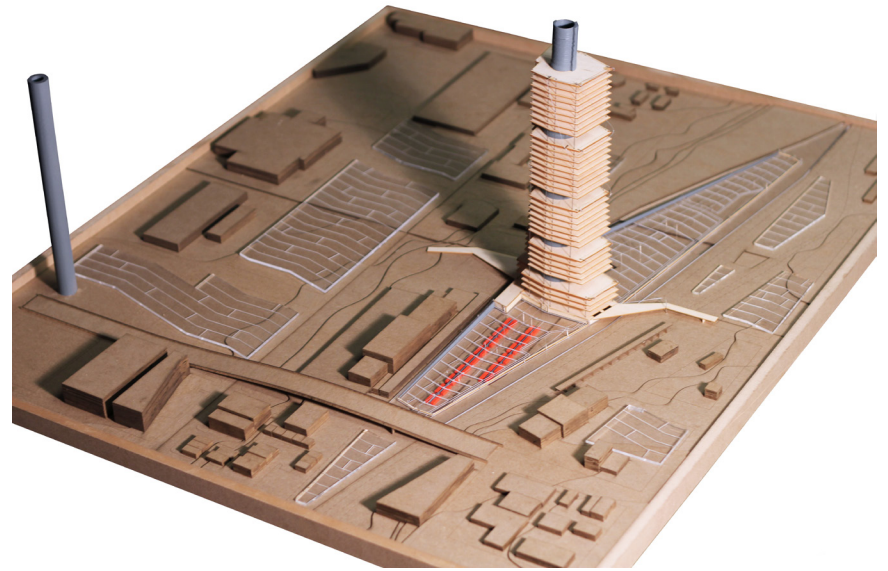
Market Lobby Overlooking East Greenhouse - Far Inside the East Greenhouse





East Greenhouse Path - South Bridge Approach





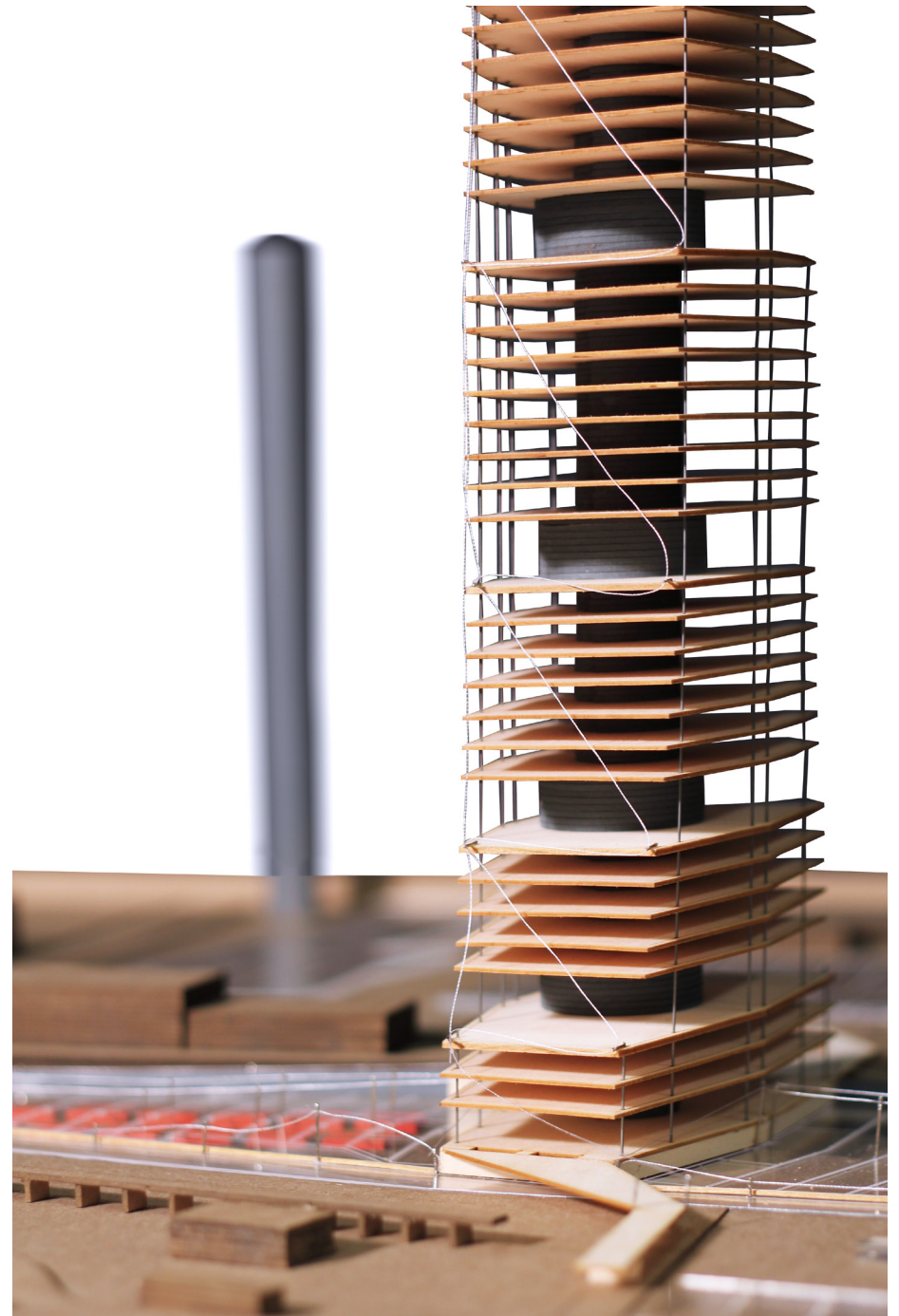
Acknowledgments

Thank you to my mentor, Brian Kelly, for being constructively critical and pushing me to search for a solution that addresses a wide range of both interesting and important architectural issues.

Thank you to my parents, Rocky and Judy Sorensen, for supporting me throughout this project and life.

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Thank you to guest jurors throughout the year for your feedback: Jeff Day, David Karle, Peter Hind, Janghwan Cheon, Nate Krug and Wayne Drummond.



This thesis project was an intense learning process for me. I learned to take criticism, reflect, and then move on with what I believed was in the best interest for the project. The fact that this began as an exploration into making golf courses more multi-functional and ended as **Harvester 1.0** is a true testament to the thesis process. At times it was difficult, and not what I expected, but in the end it is all about chasing the most intriguing and deep concepts.

That is why the performative and hybrid relationships that Harvester 1.0 starts to suggest for an architectural solution will stay with me deep into the future. Long after the model has gathered dust and the drawings have faded, the ideas and concepts behind this thesis project are what **will stick with me and not let go.**

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